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APPLIED MECHANICS REVIEWS

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TRENDS IN THE KINEMATICS OF MECHANISMS

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Literature surveys of past and present research in the field of mechanisms are available from several sources (1), (2), (3), (4), (5), (6). This review is concerned with a brief survey of the theory of mechanisms, its growth, its present state and its future development.

DEVELOPMENT OF THE THEORY

During the course of an essay on science in 1834, A.M. Ampère coined the term kinematics to designate "the mathematical investigation of the motions that take place in mechanisms and machines and the investigation of the means for creating these motions, namely, of the mechanisms and machines themselves" (7). At that time the subject entailed a description of particular mechanisms and machines together with some analysis of their motions. The early text by R. Willis (8) remains a classic written during this period. Around 1860, scientists became intrigued by the search for a mechanical means of generating an exact straight line using pivoted linkwork. Peaucellier's "cell" (9) achieved this goal in 1864, but the subject continued to spur further developments in several countries.

In England, Cayley (10), Roberts (11) and Kempe (12)—as well as others—analyzed the motion of points on the coupler, or floating link of the four-bar linkage (1875-6) and derived the geometrical and analytical properties of the "coupler curves." With the introduction of velocity and acceleration polygons in 1885 [R. Smith, *Trans. Roy. Soc. Edinburgh* **32**, p. 507], the kinematics of mechanisms reached a peak of development in the English-speaking countries, and English-language engineering texts on the kinematics of machinery have remained essentially unchanged since then. These consist of a description of particular machine elements such as cams, gears and links, and their proportions, followed by graphical (and to a much lesser extent analytical) determinations of displacements, velocities and accelerations of points on these elements.

In Germany, using projective geometry, Burmester (13) developed methods for the *approximate* generation of a straight line, such as might be useful for practical purposes, for instance, in the construction of engine-indicator mechanisms. At about the same time Reuleaux, in a pioneering text (14), introduced the notions of element pairs, links, chains, kinematic inversion and kinematic equivalence. Thereafter the three-bar linkage in the English literature was promoted to a four-bar linkage with the frame as the fixed link. The mathematical theory of coupler curves and associated higher plane curves was further elucidated, amongst others, by Mueller (15), Rodenberg (16) and Gruebler (17), the latter of whom also introduced equations for the calculation of the number of degrees-of-freedom in mechanisms.

In Russia, proceeding from the same straight-line problem, P. L. Chebychev (1853+) created the theory of polynomials deviating least from an arbitrary function. The well-known "Chebychev polynomials" were employed by Chebychev (18) in the analytical design of a variety of simple linkages generating approximate straight lines, circles, and other conic sections with minimum error.

The next major development occurred in the early 1920's when the "geometrical" school in Germany, extending the ideas of Burmester, began to formulate the concept of *kinematic synthesis*. In contrast to *kinematic analysis*-the determination of the motion characteristics of a *given mechanism*-kinematic synthesis proceeds from the *given motion requirements* to the determination of the *type and proportions* of an appropriate mechanism. Ultimately, the specification of prescribed motions may be expected to lead directly to the simplest, most reliable, and most economical mechanism, its proportions and its kinematic properties. Furthermore, this form of kinematic investigation conforms more closely to the manner in which design problems arise and has spearheaded the modern development of the subject.

For purposes of synthesis many design problems lead to the same kinematic formulation: design a mechanism, a point or link on which will generate a specified path (path generation) or execute prescribed rotations (function generation) perhaps in conjunction with a correspondingly prescribed motion of another link. Formulations of this type have led to the development of the "synthetic" or projective geometry of *finite positions of a plane* and of related higher plane curves—notably by Alt (19), Beyer (20) and Hain (21)—and to their application to fairly systematic constructions for path and function generation. The concepts employed in these constructions include the centerpoint curve, the circlepoint curve, the Euler-Savary equation, inflection circles, curvature theory, the Ball point, curves of stationary curvature and others. Within the past fifteen years this type of synthesis has been applied to a variety of reasonably simple, plane mechanisms and systematized (22).

Independently of these developments, the disciples of Chebychev and the succeeding generations—also since about 1920—attacked the subject of kinematic synthesis in Russia from a primarily analytical point of view. Polynomial-approximation techniques were refined and improved; parametric techniques (23), least-square methods (24), and others were applied to plane mechanisms synthesis with minimum error. In 1940, S. Sh. Blokh (25) introduced complex-number methods in kinematic synthesis which, with the aid of matrix

algebra, were developed by Blokh to an advanced state in 1944 (26). Other resources of the applied mathematician were beginning to be exploited: in 1948, F. M. Dimentberg directed attention toward the use of dual numbers ($z = x + e\gamma$, $e^2 = 0$) to the study of spatial motions; the possibilities of tensor analysis in three-dimensional mechanisms were examined by Kislitsin (28) in 1954. A modern and thorough text on the subject, mentioning some of these developments, has been written by I. I. Artobolevskii (3).

KINEMATICS IN THE U.S.A. AND RECENT DEVELOPMENTS GENERALLY

Until the past year or two the ideas of kinematic synthesis remained essentially unnoticed in American textbooks and the subject was not actively pursued until toward the end of World War II. At that time the need for mechanisms in the field of fire-control instrumentation led A. Svoboda at the M.I.T. Radiation Laboratory to develop nomographic techniques for mechanisms synthesis for use in military applications (29). This fact and several review articles on the subject (7), (30), (31), (32), have aroused interest in kinematics and brought forth efforts to (a) become acquainted with European developments, (b) develop the subject of kinematic synthesis within the U.S.A. It may be mentioned in this connection that in the course of a recent visit of Academician I. I. Artobolevskii (3), (26), it was reported by that scientist that at one of their recent meetings—perhaps, such as (33)—"800 active workers in the field attended."

The traditional American interest in classical kinematics and in acceleration analysis has persisted [an outstanding example is Goodman (34)], but several universities, including Columbia, Cornell, M.I.T., Northwestern and Purdue, are active also in the field of mechanisms synthesis. The following activities have been observed:

(a) The compilation of atlases of point-path trajectories of points on moving links (35) and of corresponding rotations of two links (36). Useful as these are, the variety of motion even in simple linkwork is so tremendous that such volumes tend to be very bulky.

(b) Conferences, meetings, survey articles and books for the dissemination of information concerning the more recent developments, (7), (30), (31), (32). Five conferences on mechanisms (resulting in published transactions) have been held at Purdue University (1953, 1954, 1956, 1957, 1958) under the joint auspices of Purdue University and Machine Design. One English text (from Australia) on modern kinematic analysis (mainly the Euler-Savary equation) appeared in 1953 (37) and specific technical interpretations of European developments, such as (38), for instance, have been rendered in the technical press.

(c) Original contributions: (these of course include item (a). The algebraic synthesis of four-bar mechanisms for prescribed corresponding crank rotations was described in 1955 (39). A study on the classification of mechanisms and their motions was published by Denavit and Hartenberg (42) in 1955 using matrix concepts; this theory has been extended by Denavit (1958) toward the analysis and synthesis of three-dimensional mechanisms using dual matrices and the Cayley-Klein parameters (43). The complex-number-matrix method initiated by Blokh (26) has been extended, generalized for plane mechanisms, applied to a variety of mechanisms, and programmed for automatic digital computers (40), (41). These investigations by no means complete the list, but they are believed characteristic of perhaps the most significant American development: the application of large-scale, programmed digital computers to the field of mechanisms (41), (42), (43), (44). The ever-increasing complexity and more stringent performance requirements of machinery and mechanisms appear to have made a more scientific approach to the theory of motions necessary, and in addition, modern developments such as high-speed computers with logic circuits have made it possible to deal economically with the large number of variables occurring in the analysis of these motions.

Meanwhile the postwar years have seen related developments on the continent. Representative among these are attempts to develop kinematics by group and set theory (45), (46); systematic research and development of spatial mechanisms by Beyer and his school (47), (48), (49), (50); the establishment of a Russian technical journal devoted to articles by many Russian scientists on all aspects of the subject [*Trudi Seminara po Teorii Mashin i Mekhanizmov*, Academy of Sciences, USSR—since 1948] in quantity and in depth; some expositions and developments in pure (mathematical) kinematics with emphasis on geometry (51), (52), (53), (54); investigations, here and abroad, on the effects of dimensional errors and tolerances on the kinematic behavior of mechanisms (55), (56), (57), (58); classification of mechanisms (3), (59); noncircular gearing (60); harmonic analysis of mechanical motions (61); and complex number methods (62), (63).

THE FUTURE OF THE KINEMATICS OF MECHANISMS

The ultimate question of kinematics—synthesizing the right mechanism from the design requirements—will probably never be answered completely, but in the course of the search the question will be phrased more precisely, and in the process yield information. In *control* applications, where no mass and inertia is *a priori* involved, the field of mechanisms seems limited; in power and motion applications, however, where mass and inertia is *necessarily* involved—and this includes the whole field of light and heavy machinery, instrumentation, automation, instruments, engines and moving equipment—the possibilities of mechanisms are as yet largely unexplored. The tools and techniques of modern applied science, especially of mathematics, will serve to explore this field, which has been relatively neglected in this respect. A few major trends are already in evidence:

1. Further application of linear algebra to the analysis and synthesis of a wider variety of plane mechanisms, using programmed computers. Specifically, application to mechanisms such as four-link mechanisms with coupler curves, more complex linkages such as two-degree-of-freedom systems, five and six-bar linkages, mechanisms in series and geared linkages are involved. In addition to path and function generation, a true understanding of these mechanisms requires knowledge concerning maximum number of specifiable conditions, existence theorems, structural errors, mechanical advantages, transmission angles, proportions, ranges, velocities, accelerations and the like.

2. Application of dual numbers, dual matrices and tensor analysis for the same purpose (and also using programmed computers) in three-dimensional mechanisms. Such mechanisms may offer space advantages and possess a greater variety of motion characteristics (variable helicity in an output motion, for instance). Research on spatial four-bar linkages and spherical four-bars—to mention just one type of mechanism—is approximately a decade old and the design for prescribed motions, accelerations, transmission angles, and path and function generation still remains to be firmly established.

3. Investigations concerning mechanism classification and general theorems dealing with the varieties of attainable motions. These call to mind the classification scheme of the chemical elements and the network synthesis techniques in electrical communications, the aim of which has been to render more predictable the multitude of different combinations of elements and their resulting properties. This might be called the establishment of a "second law" of kinematics. For example, a positive, infinitely variable, mechanical speed transmission is generally considered a theoretical impossibi-

ity; but why? Conceivably such an analysis in its eventual state might borrow from group concepts. The subject in some form has attracted scientists for a long while. Reuleaux invented a shorthand notation for mechanisms based on the character of the connections between kinematic elements; the notation was of limited success. Assur (see (3)) developed related schemes around 1910. Franke (59) has attempted a more general but descriptive theory, including in it hydraulic and electrical elements. Denavit and Hartenberg (42) have used a matrix transformation to characterize the transformation of motion between adjoining kinematic elements in an effort to extend the work of Reuleaux. Related results using group theory were initiated by Kalitzin (45), (46), and various Russian scientists (Artobolevskii, Dobrovolskii) have been active in the field. The subject is unwieldy in that the number of independent variables is undesirably large, but the rewards for success appear to be substantial.

4. Collection, arrangement and organization of the research already uncovered and presentation of this knowledge in a manner deemed to be useful to the designer. Such presentations (64), (65), (66), which require originality and thoughtfulness, are already in print.

Among the numerous topics not dwelt upon here is the whole extensive subject of gearing; the kinematics of cams (67); high-speed and intermittent mechanisms (68), (69); special topics in spatial mechanisms (70); self-adjusting mechanisms (71); and many others. The references throughout this article are necessarily incomplete and many investigators, reference to whose works had to be omitted due to space limitations, have done much to foster the subject. If, in the course of this review the reader has caught some of the beauty and precision and some of the spirit of opportunity pemeating this very old and very new discipline, the review will have succeeded indeed.

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Analytical Methods in Applied Mechanics

(See also Revs. 4270, 4276, 4290, 4298, 4309, 4405, 4483, 4644, 4716, 4784)

Book—4260. Faddeeva, V. N., Computational methods of linear algebra (Translated from Russian by Curtis D. Benster), New York, Dover Publications, Inc., 1959, x + 252 pp. $1.95. (Paperbound)

This worthy volume by Mrs. Faddeeva presents an excellent balance between theory and practice of matrix algebra. It incorporates a wealth of material and is valuable as a text and guide for linear computational problems. The book is divided into three chapters. The first gives basic linear algebra material including vector spaces, linear transformations, Jordan canonical form and limit concept for vectors and matrices. The second chapter deals with systems of linear equations, while the third chapter takes up eigenvalue problems. Many numerical examples (the principal tables have been recomputed by the translator) are provided to illustrate the theory. The printing and format are excellent.

Y. L. Luke, USA

Book—4261. Duschek, A., Lectures on higher mathematics. Vol. I. Integration and differentiation of functions of one variable, applications, numerical methods, algebraic equations, infinite series [Vorlesungen uber höhere Mathematik. Erster Band. Integration und Differentiation der Funktionen einer Veränderlichen, Anwendungen, numerische Methoden, algebraische Gleichungen, unendliche Reihen.], 2nd ed., Wien, Springer-Verlag, 1956, xi + 440 pp. $11.45

This excellent, enjoyable, authoritative, detailed presentation is less advanced than seems at first sight since it is the first of a four-volume work. Some difficult items are deferred to later volumes (e.g. proof of Euler's theorem to Vol. 3, and detailed treatment of Stieltjes integral to Vol. 4) while needed results are stated so elements of the topics can be given. Surprisingly, author introduces sin, cos, tan, cot, but not sec, cosec. Treatment has depth and adequate rigor. Author has admirable pedagogical skill; he makes difficult concepts absorbingly clear. Brief biographical notes on principal mathematicians are included. Appendix gives full solutions of exercises.

B. Hoffmann, USA

4262. Goldstine, H. H., Murray, F. J., and von Neumann, J., The Jacobi method for real symmetric matrices, *J. Assn. Comput. Machy.* **6**, 1, 59–96, Jan. 1959.

Paper reviews classical procedures for solution of eigenvalue problem. These include methods for computation of characteristic equation and serial determination of eigen elements by matrix iteration. For the most part, for matrices of order $n \sim 100$, the methods are not suitable for large-scale fully automatic equipment either because of stability or because considerable mathematical judgment must be made as solution unfolds, which implies human interference with the machine. Authors discuss in detail a rotational method (originally devised by Jacobi) for determination of eigenvalues and vectors. Various properties of the algorithm are derived, and useful numerical estimates for stability and convergence are developed. Practice indicates that convergence is much faster than that predicted by theory.

Y. L. Luke, USA

Book—4263. Golab, S., Tensor calculus [Rachunek Tensorowy], Warszawa, Panstwowe Wydawnictwo Naukowe, 1956, 309 pp. Cena zl. 30.70.

This is actually the course on tensor calculus given in one of the universities in Poland. Chapter I contains the fundamental notions of the analytic spaces, groups, pseudo-groups, geometry of spaces, subspaces, coordinate systems, etc. Chapter II refers to geometric elements: vectors, convariant and contra-variant vectors, fundamental vectors. Chapter III: afinors, unit afinor, algebra of afinors, linear dependence of afinors, contraction, symmetrization, antisymmetrization, multivectors, densities, space

orientation, tensors, metric tensor, scalar product, geometric interpretation of tensors, Ricci vectors, vector product, canonical form of the fundamental tensor, etc. Chapter IV: Operations on tensors, aholonomic systems, Hesian of a scalar field, Piencow objects, gradient of density, divided afinors, afinor density, afinor fields, etc. Chapter V considers derivative of a vector along a curve, absolute derivative, object Γ_{μ}, symmetrical and antisymmetrical parts of an object of parallel translation, covariant derivative, curvature afinor, parallel translation in Riemann space, Christoffel symbols, a moving geodesic system, absolute derivative, derivative of a unit afinor, geodesic lines of the space L_n, afine parameter on a curve, local geodesic coordinates, etc. Chapter VI discusses curvature afinor, double differentiation, interpretation of the afinor $S^{\lambda}_{\mu\nu}$, etc. Chapter VII deals with the space metrics: Christoffel symbols, unique distinction of the linear object of translation for the Riemann space, properties of Christoffel symbols, constant afinors with respect to a covariant differentiation, lengths and angles in Riemann space, problem of selection of $G_{\lambda\mu}$ to $\Gamma^{\lambda}_{\mu\nu}$, relations between coordinates of a curvature afinor, Bianchi identity. Chapter VIII: Weyl's spaces, afino-Euclidean spaces, metric-Euclidean spaces, polar coordinates. Chapter IX: differential operators, integral theorems, invariant differential operators, theorems of Green, Stokes, Gauss-Ostrogradskii, definite multiple integral. Chapter X: application of tensor calculus to geometry, geodesic lines as extrema of a variational problem, geometry of embedded spaces, space V_{n-1} embedded in the space V_n, curvature vectors, relative curvature vectors, asymptotic lines, spherical points, curvature lines, equations of Gauss and Mainardi-Codazzi, differential parameters of Beltrami, Frenet equations.

The book closes with the list of symbols and bibliography. The contents cover wide material, using the references from both the Western and Russian literature. Printing is good.

M. Z. Krzywoblocki, USA

4264. Milnes, H. W., and Potts, R. B., Boundary contraction solution of Laplace's differential equation, *J. Assn. Comput. Machy.* **6,** 2, 226–235, Apr. 1959.

A numerical method is introduced for solution of the Dirichlet problem within a circle. The data prescribed on the original boundary are used to compute the solution at mesh points on a concentric circle of slightly smaller radius, thereby defining another boundary-value problem over the smaller circle. The solution for the entire region is obtained by successive contractions of the boundary in this way. Appropriate approximating relations are presented and their stability is discussed.

From authors' summary by Y. L. Luke, USA

4265. Pasta, J. R., and Ulam, S., Heuristic numerical work in some problems of hydrodynamics, *Math. Tables Aids Comput.* **13,** 65, 1–12, Jan. 1959.

This interesting paper studies basic approaches for the solution of multi-dimensional continuum problems on large-scale digital computers. Several novel descriptions of the physical model at the molecular and multi-molecular level are introduced. The various complications are analyzed and techniques for solution are proffered. To test some of the ideas, authors study the motion of a heavy fluid on top of a lighter one—the Taylor instability configuration. The latter problem in its initial stages was also studied experimentally (that is, in the physical sense) and the configuration of the two gases are "not unlike" those obtained numerically. Y. L. Luke, USA

Book—4266. Barnes, R. M., Work sampling, 2nd ed., New York, John Wiley & Sons, 1957, x + 283 pp. $7.95.

Book is of special interest to industrial engineers. Author gives a clear and rather complete exposition of the tool of work sampling, which permits measuring activities and delays of people and machines and, in some cases, establishing a time standard for an operation.

Author covers in the first few chapters all statistical concepts needed for an understanding of the method and procedure. No prior statistical knowledge is required by the reader. Procedure for planning and organizing a work-sampling study and the procedure to be followed for measuring work by sampling are clearly described, and practical cases illustrate it.

Book contains several applications of work sampling of special interest to supervisors, managers and those who plan and control activities of men and machines. P. Nesbeda, USA

Book—4267. Selfridge, R. G., and Maxfield, J. E., A table of the incomplete elliptic integral of the third kind, New York, Dover Publications, Inc., 1958, xiv + 805 pp. $7.50.

Title transcendent is $\Pi(\varphi, \gamma^2, k) = \int_0^{\varphi} (1 - \gamma^2 \sin t)^{-1} (1 - k^2 \sin t)^{-1/2}\, dt$. Volume gives 6 decimal tables for $\gamma^2 = -1(.05) - .1(.02) - .02, .05(.05) .5(.02) .8(.01).99$; $k = \sin\theta$, $\theta = .1(.1)1.5$; and $\varphi = 0(.01)\ 1.57, \pi/2$. If $\gamma^2 > 1$ or $0 < \gamma^2 < k^2$, the integral can be evaluated using available tables of Theta and Jacobian Zeta functions of real arguments. If $k^2 < \gamma^2 < 1$ or $\gamma^2 < 0$, the arguments of the latter functions are complex and no tables exist. Thus present work contains much new material. Some formulas and a description of the computational method is presented in the introduction. On each page of the tables the heading γ should read γ^2.

Y. L. Luke, USA

Computing Methods and Computers

(See also Revs. 4260, 4261, 4262, 4265, 4287, 4312, 4507, 4575, 4584, 4806)

4268. Maley, C. E., A simplified numerical analysis, *J. Roy. Aero. Soc.* **63,** 577, 59–62 (Tech. Notes), Jan. 1959.

Linear and higher polynomial approximations are developed with systematic use of "clusters" (i.e., Vandermonde's determinants) and so-called "plats" (i.e., corresponding matrices). Difference formulas are derived for interpolation, differentiation, integration, zeros and critical values of a function, and least-square curve fitting.

There are no new results, but author emphasizes that his calculus has proved satisfactory as a "lingua franca" between engineers and engine programmers. R. Sauer, Germany

4269. Schlechtweg, H., Estimation of the remainder in a mean value formula for approximate numerical integration (in German), *ZAMM* **37,** 9/10, 353–361, Sept./Oct. 1957.

If an integral $\int_a^b f(x)\,dx$ is numerically approximated by a sum of the form $\sum_{\nu=1}^{n} A_\nu f(x_\nu)$, it is known that bounds for the error of the approximation can be given in terms of the derivatives of $f(x)$. The present paper derives error bounds which are far more accurate than those commonly used. The expressions for such bounds are involved; for the general n-point quadrature formula above, an error bound involving more than 10 n terms is given. If, however, the abscissas x_ν are equidistant, the expressions can be greatly simplified, and their coefficients can be precomputed once for all. For instance, if an odd number of equidistant abscissas (including the end points a, b) is used, the error bound may be written as $\sum (\alpha_\nu \Phi_\nu - \beta_\nu \varphi_\nu)$, where Φ_ν and φ_ν are upper and

lower bounds of $f'(x)$ in the ν-th subinterval, and α_ν, β_ν are given numerical coefficients. For an even number of abscissas, the formula contains two more terms, involving coefficients γ_ν, under the summation sign. The paper concludes with a tabulation of the coefficients α_ν, β_ν, γ_ν for values of n up to 7.

Most computers find it too cumbersome to determine estimates separately for each subinterval. The method will therefore be found useful only when it is important that the error of the numerical quadrature be estimated very accurately. For such cases, although the notation of the paper is cumbersome (it has been simplified for this review), the final method is simple to apply.

F. L. Alt, USA

4270. Milne, W. E., and Reynolds, R. R., Stability of a numerical solution of differential equations, *J. Assn. Comput. Machy.* **6,** 2, 196–203, Apr. 1959.

In 1926, the first-named author presented a "predictor-corrector" method for the numerical solution of differential equations. The "corrector" formula is Simpson's rule for integration. Under certain conditions the integration process is unstable, since it can produce an error which alternates in sign from step to step with exponential increase in magnitude. Authors show that occasional application of Newton's "three-eights" formula can effectively damp out the unstable oscillation without injury to the desired solution. Some numerics are presented to illustrate the discussion.

Y. L. Luke, USA

4271. Goodey, W. J., Note on the solution of non-linear simultaneous equations by successive approximations, *J. Roy. Aero. Soc.* **62,** 572, 603–604 (Tech. Notes), Aug. 1958.

4272. Proceedings of the colloquium on numerical computation, Caen 1955–Dujon 1956, *Publ. Scient. Tech. Min. Air, France NT* 77, 141 pp., 1958.

Book—4273. Stibitz, G. R., and Larrivee, J. A., Mathematics and computers, New York, McGraw-Hill Book Co., Inc., 1957, vii + 228 pp. $5.

This little book is addressed to the layman with very little mathematical training. It introduces him to the methods and spirit of certain facets of Applied Mathematics.

Chapter 1, entitled "Mathematics, computers and problems," gives a lively and easily understood introduction to the subject. The authors' warning "A numerical statement expressed in many digits exerts a hypnotic effect that puts our sense of caution to sleep, particularly if the statement is found at the end of a long computation." is also appropriate for an audience considerably more sophisticated than the one to whom the book is directed. Chapter 2, "Applied mathematics and solutions," is an entertaining discussion of the history of Fashions in Solutions. Chapter 3, "Kinds of problems and where they come from," is an agile survey, containing the following rather irreverent passage "The school books inform us of the activities of the characters A, B, and C who go about plowing fields, rowing boats with and against the current, separately and in various combinations. The books assume that the amount of work each man does is proportional to the time he spends on that work, regardless of what the others are doing and of how long he has been at work. They assume that each man in a joint undertaking works at the same rate he would if working alone, thus ignoring the likelihood that one of the three will show qualities of leadership and so will do no work at all." Chapter 4, "History of computers," gives a clear 20-page survey, stopping short of the recent developments. Chapter 5, "Numerical analysis," touches: the difficulties of computing with approximate numbers, binary notation, iteration, interpolation, partial differential equations. Let us hope that the lay reader will appreciate this material. Chapter 6, "Digital computer components," and Chapter 7, "Logical design of digital computers," offer a clear introduction to the subject, but Chapter 8, "Analog computers and simulators," will strike people in this field as seriously out of date, since the emphasis is on mechanical systems, with very little mention of electronic computers, whose use is now quite widespread. Chapters 9, 10, 11, "Computing with random numbers," "Computer errors," and "Computers at work," are entertainingly written and round out the book.

For people in this field the book provides light and often delightful reading. It is doubtful that the intended audience, the completely untutored reader, will understand everything; but certainly a large portion of the book is within the grasp of any literate person.

H. D. Block, USA

4274. Tuck, H. R., and Galin, R., The application of a digital computer to the design of air conditioning system components, *G M Engng. J.* **5,** 3, 17–21, July–Aug.–Sept. 1958.

4275. Bretton, D. M., The use of electronic digital computers in structural engineering, *Struct. Engr.* **36,** 9, 302–309, Sept. 1958.

4276. Franklin, J. N., Numerical stability in digital and analog computation for diffusion problems, *J. Math. Phys.* **37,** 4, 305–315, Jan. 1959.

Paper reviews previous work concerning stability of difference operator for numerical solution of diffusion problems. In a certain sense author shows that explicit difference schemes with maximum stability are given by polynomial operators of Chebyshev type whose arguments are spatial-difference operators used in analog computation. Numerical experiments with third-order operator verify theoretically predicted increase in stability.

Y. L. Luke, USA

4277. Bogdan, R., Pelecudi, Cr., and Calmaciuc, L., Study on the mechanical transducers for the determination of paths in plane mechanisms, in Cartesian or polar coordinate systems (in English), *Bul. Inst. Politehn. Iasi* **4,** 1/2, 315–326, 1958.

Paper concerns a new experimental device for determining the path of various points in a plane mechanism. The apparatus includes a mechanical transformer acting on a transducer which converts the displacements into corresponding electrical quantities. By means of these transducers, output voltages are obtained, proportional to the displacement of a point in Cartesian or polar coordinate systems. For eliminating the systematic errors due to the finite lengths of the connecting rods when using Cartesian coordinates, an electric compensation system is studied which reduces these errors to values 1% lower than the measured quantities. By means of an electric device the path is obtained, after amplification, on an oscilloscope screen. The device may use either d c or a c current. By using polar coordinates one may determine paths situated on large surfaces (the surface investigated by authors is a square of 4-ft sides). Photographs indicating the paths of various points of a connecting rod show the interesting possibilities provided by this device.

Taking into account the operation rapidity, the device may be considered as a valuable instrument for determining the operation characteristics of plane mechanisms.

N. Tipei, Roumania

4278. Freudenstein, F., Five-line construction for a computing linkage satisfying five precision requirements, *J. Appl. Mech.* **24,** 4, 621–622, Dec. 1957.

Analogies

(See also Revs. 4277, 4417, 4554, 4716)

4279. Tanabe, Y., and Yamada, S., Electrolytic tank analogue design and application of automatic control, *Sci. Rep. Res. Inst. Tohoku Univ. Japan (A)* **10,** 2, 133–174, Apr. 1958.

Paper comprises an exhaustive study of the automation of mapping equipment used with electrolytic tanks and of news of improving accuracy of measurement.

Remark on the essential problems *re* gain of accuracy and speed in use of electrolytic tanks, a review of previous work by others, and a summary of the present work open the paper. Sketch of general theory underlying use and of the principal features of construction is followed by detailed study of the perturbations caused by insertion of the probe, polarization of electrolyte, effect of surface tension, and mechanical errors, in the associated pantograph equipment, etc. The causes, effects and minimization of each are exhaustively investigated.

Next, detailed design of a superior type of automatic equipotential line plotter using servomechanism techniques is advanced, and the quality of its performance illustrated by several equipotential maps. A lengthy section details use for automatic tracing of electron trajectories in an electrostatic field: mechanical design, electrical circuits and quality of performance are discussed in detail. An Appendix describes a "new type" of a c potentiometer by which amplitude and phase difference of a c voltage can be measured. It comprises a useful instrument for detecting rapidly the resistance of an electrolytic or the probe impedance; also it serves as an auxiliary in designing the servo systems.

Several photographs of the equipment, numerous circuit diagrams, and various equipotential maps illustrate and illuminate the context. This paper, a most excellent one, is MUST reading for all interested in analog work, and in use of electrolytic tanks in particular. T. J. Higgins, USA

4280. Janssen, J. M. L., and Offereins, R. P., The use of an electronic simulator in achieving optimal adjustment of a controller (in German). *Regelungstech.* **5,** 8, 264–270, 1957.

4281. Abramson, H. N., Theoretical investigations of the four-electrode crevasse detector, *Trans. Amer. Geophys. Un.* **38,** 6, 849–856, Dec. 1957.

Analyses based on general electromagnetic field equations were undertaken, but these proved tractable only for rather simple cases not extending to the presence of a cavity. After a study indicated magnetic induction effects to be negligible, analysis of the electrostatic field led to an expression for the potential at any point in a field, with allowance for the presence of a spherical or cylindrical cavity. A numerical solution of the Laplace equation afforded another technique, using the Southwell relaxation method. A third approach was to model the problem in a plane, using conducting paper to obtain an analog solution. Comparison of analog and numerical solutions with the analytical solution for the case of no cavity indicated the merit of the former. In general, the analog technique was found to be the most expeditious one, and it is flexible as to the shape of the cavity cross section. Specimen curves and tables given in the paper are expected to be useful in further studies. T. J. Higgins, USA

4282. Il'enko, D. V., Determination of deflection and torsion moments in simple intercrossing and broken (in plane) beams (in Russian), Electrical modelling of beams and frames, Taganrog, 1956, 50–58; *Ref. Zh. Mekh.* no. 10, 1957, Rev. 12077.

4283. Agaguseinov, Yu. A., and Ashurli, S. I., Investigation of the stressed condition of the components of an industrial technical oil plant (in Russian), *Trudi Azerb. N.-i. In-ta Neft. Mashinostr.* no. 1, 120–140, 1956; *Ref. Zh. Mekh.* no. 11, 1957, Rev. 13490.

On the basis of the generally known relations of static similarity in modelling recommendations are made regarding the selection of size of the models, having in mind the permissible margin of error in the conditions adopted of making measurements for deformation by means of electric strain gages. Results of the experimental investigations on the distribution of stresses in the bends are compared with the theoretical stresses computed by the methods of Grashoff, of Belyaev, by graphoanalytical and by numerical integration. The deduction is made that the most acceptable, because of its accuracy, is the Grashoff method. Recommendations are made for the use of alloy steels for the bends instead of the usual carbon steels. A. M. Sinyukov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4284. Zhoukovsky, M. I., Application of hydro-gas analogy for an approximate investigation into supersonic flow in the profile gratings (in Russian), *Teploenergetika* no. 2, 19–33, Feb. 1959.

4285. Molnar, L., Determination of the laws of the streaming of liquids by the aid of electrical analogies (in Hungarian), *Hidrológiai Közlöny* **37,** 4, 306–317, 1957.

4286. Ivicsics, L., Scale model test of settling basins (in Hungarian), *Hidrológiai Közlöny* **37,** 3, 223–225, 1957.

Scale models of settling basins can either be distorted or undistorted and the interrelation between the dimensions and quantities of the model and that of the prototype will be in either case indicated by the Froude number. The distortion of the model usually becomes necessary in case experiments are carried out with silt-charged water. According to a method of distortion, sediment with equal settling velocity w_t is applied both in the model and in the prototype. In case of experiments with silt-charged water—both with distorted and undistorted models—the decrease in the vertical settling velocity of sediment particles owing to turbulence should be borne in mind when selecting the sediment to be applied; this may be performed with the aid of velocity attenuation curves. From author's summary

4287. Tribus, M., The use of analogs and analog computers in heat transfer, Oklahoma State Univ., Engng. Exper. Sta. Publ. no. 100, 84 pp., May 1958.

These notes represent a summary of lectures delivered at Oklahoma State University May 9 and 10, 1957 for members of the Fourth Annual Heat Transfer Conference. Ed.

4288. Vamos, T., and Lengyel, Gy., Electronic boiler-model (in Hungarian), *Meres es Automat.* **6,** 7/8, 229–232, July/Aug. 1958.

In order to perform rapid calculations of transfer functions and to adjust control devices of drum-type pulverized coal-firing boilers, an electronic boiler-model has been constructed. This can be used for the investigation of both frequency-response and transient-response. Article deals with the circuit of the model, the approximations and the measuring methods applied.

From authors'summary

4289. Aleskerov, S. A., Babich, Yu. A., Motyakov, V. I., and Chal'yan, K. M., Experimental solution of problems, described by Fourier's equation, on the electrical model EM-8 (in Russian), *Izv. Akad. Nauk AzSSR* no. 1, 21–29, 1957; *Ref. Zh. Mekh.* no. 11, 1957, Rev. 12925.

Results are given of some experimental investigations on the modelling apparatus EM-8, the model having been designed and made at the Institute of precise mechanics and calculating technics

of the Academy of Science, SSSR. A series of experimental solutions for a differential equation of the parabolic type were carried out on this device.

$$\frac{\partial}{\partial x}\left(A\frac{\partial U}{\partial x}\right)+\frac{\partial}{\partial y}\left(B\frac{\partial U}{\partial y}\right)=C\frac{U}{t}$$

where A, B, C are known functions of points (x,y). The solution sought for $U(x,y,t)$ is determined from the boundary stationary conditions and from the initial condition $U(x,y,t)\big|_{t=0}=f(x,y)$. The modelling of the process is carried out with the aid of a network of resistances and capacitances. The results of the experimental solution of the problems, derived from the theory of filtration of an elastic liquid and from the theory of heat conductivity, are compared with the known approximate or precise analytical solutions. From the examples given and from the comparative analysis a deduction is put forward regarding the expediency of using the proposed method for the solution of practical problems.

V. N. Nilatovskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Kinematics, Rigid Dynamics and Oscillations

(See also Revs. 4299, 4327, 4444)

Book—4290. Research in mechanics and applied mathematics. Vol. I [Issledovaniya po mekhanike i prikladnoj matematike], Moscow, Gosud. Izdat. Oboron. Prom., 1958, 220 pp. 9.65 rubles.

This monograph contains fourteen articles from various branches of theoretical mechanics and applied mathematics. First come seven themes on the mechanics of deformable bodies, three contributions are devoted to hydro- and aeromechanical subjects, then follow three advanced mathematical problems, and the collection concludes with a brief theme from the sphere of numerical methods in mathematics. Technicians' attention should be paid especially to selected questions from elasticity, anisotropic plasticity, etc.

The book will prove very useful to engineers and research workers with an adequate mathematical equipment.

V. Vodicka, Czechoslovakia

Book—4291. Bolotin, V. V., Dynamic stability of elastic systems (in Russian), Moscow, Gostekhizdat, 1956, 600 pp. + illus. 16r 50k; *Ref. Zh. Mekh.* no. 11, 1957, Rev. 13139.

This is a systematic exposition of questions in the theory of the dynamic stability of elastic systems. The introduction consists of a short account of the history of the question. In the first chapter methods are examined for the determination of region boundaries of dynamic instability. The second chapter deals with the investigation of the effect of damping on the regions of dynamic instability. The influence of nonlinear factors (nonlinear elasticity, nonlinear inertia, nonlinear damping) is the subject matter of the third chapter. In the fourth chapter the known methods of solution of problems on natural and constrained vibrations of nonlinear systems are expounded. The determination of vibration amplitudes in the presence of the principal parametric resonance is dealt with in Chapter V. In Chapter VI the process of establishing vibrations appearing near the principal resonance is studied. The seventh chapter is devoted to the question of subsidiary resonance. In Chapter VIII the problem is analyzed of the reciprocal action of constrained and parametric excited vibrations. The ninth chapter is given up to a study of vibrations of systems with periodically changing stiffness and the vibrations of systems with periodically varying mass.

The subject dealt with in the second part of the book is the general theory of dynamic stability of elastic systems. In the tenth and eleventh chapters the essentials are set out for further elucidation arising from the theory of matrices and the theory of linear integral equations. Chapters XII and XIII are devoted to the differential equations of the dynamic stability of rods and elastic systems. In the fourteenth chapter information is given for the theory of differential equations with periodic coefficients and the question is studied on the building up of regions of dynamic instability. Here the matrix method for solving the problem is developed in detail. Problems on the dynamic stability, taking into account the damping effect, form the subject matter of Chapter XV. In Chapter XVI the bases of the nonlinear theory of dynamic stability are gone into.

The third part of the book is devoted to the applications of the general theory, by means of concrete examples. Here analyses are given for: (1) The dynamic stability of rectilinear rods (Chapter XVII); (2) The problem of the dynamic stability of thin-walled rods in a nonlinear setting (Chapter XVII); (3) The dynamic stability of curvilinear rods (Chapter XVIII), in particular of arches; (4) The dynamic stability of a plane form of deflection (Chapter XIX); (5) The dynamical stability of statically indeterminate frames (Chapter XX); (6) The dynamical stability of plates (Chapter XXI); (7) The dynamic stability of shells (Chapter XXII).

The results of the experimental investigations are given in a systematic form. The solutions of particular problems are continued to their final results form. An extensive bibliography is supplied in the form of footnotes.

G. Yu. Dzhanelidze

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4292. Collection of papers on questions relating to dynamics and dynamic strength, 2nd ed. (in Russian), Riga, Izd-vo Akad. Nauk LatvSSR, 1954, 168 pp. + illus. 62.45k; *Ref. Zh. Mekh.* no. 11, 1957, Rev. 13455.

Book contains the following papers: A. K. Malmeister, Deformation and stability of a system, capable of duplication; G. Ya. Kunnos, Free vibrations of bridges of combined systems; D. I. Gol'tsev, Fatigue endurance of metals subjected to deflection with torsion in conditions of asymmetrical loading cycles; Ya. Ya. Ulpe, Hysteresis losses in wood during asymmetrical cycles; Ya. G. Panovko, Principles of vibration damping in elastic systems with hysteresis; B. Ya. Tarasov, The bond between the force and the residual deformation during impact tests; A. M. Strekis, Constrained vibrations of systems with one step of freedom in the presence of damping and an arbitrary exciting force; V. P. Viksne, Vibrations of beams lying on an elastic-massive foundation; V. F. Lukovnikov, The application of the Bubnov-Galerkin method to the investigation of three-dimensional stability of thin-walled rods.

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4293. Kartvelishvili, N. A., Stability of small oscillations of dynamic systems containing small parameters (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 9, 19–26, Sept. 1957.

The investigation of stability of dynamic systems with many degrees of freedom, especially energy systems, requires the solution of characteristic equations which are both complex and unwieldy. The question arises whether it is not possible to reduce the investigations of the characteristic equation of a given system to the solution of a very few simple equations.

With the exception of a few cases where one can neglect the small (nondiagonal) elements of the characteristic determinant and it is possible to reduce this determinant to a product of two or more determinants, the possibility of simplification presents itself in cases when a few of the differential equations of small oscillations of the system contain small constants of time.

From author's summary by M. Maletz, USA

4294. Anderson, V. Ya., Conditions of stability and instability of linear systems with two degrees of freedom (in Russian), *Ucb. Zap. Gor'kovsk. In-ta* **35**, 202–219, 1957; *Ref. Zh. Mekh.* no. 10, 1957, Rev. 11243.

With the object of critically analyzing Rocard's statements [J. Rocard, "General dynamics of vibrations," Paris, 1948], an investigation was made of the conditions met with in self-excitation of linear systems with two degrees of freedom. The forces acting on the system are subdivided into conservative, dissipation and active forces. To the active forces are referable the forces of negative dissipation and the directed bonds. The separating out of the regions of stability and instability is done by plotting the corresponding Vyshnegradskii curves. It is shown that the formation of unstable conditions is possible because of negative dissipation or the presence of a reverse bond. The conditions of stability and instability were specially investigated in systems close to the linear conservative. It was shown that the principal role in the emergence of instability was played by the extent of the linkages. [L. I. Mandel'sztam, "Complete collection of works." Vol. 4. Izd-vo Akad. Nauk SSSR, 1955.] The paper is illustrated by a large number of examples.

N. V. Butenin
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4295. Voznyuk, L. L., The stability of periodic solutions of equations of a high order (in Russian), *Dopovidi Akad. Nauk URSR* no. 1, 13–17, 1957; *Ref. Zh. Mekh.* no. 3, 1958, Rev. 2602.

The stability is examined of the periodic solution of equation

$$R(p)\,z = \epsilon\Phi(z, \epsilon) \qquad \left(p \equiv \frac{d}{dt}\right) \qquad [1]$$

where ϵ is the small positive parameter, $R(p)$ the analytical function p, $\Phi(z, \epsilon)$ has a sufficient number of continuous derivatives along z and analytical relative to ϵ. After the exchange $x = v(\varphi)\exp(qt)$ the following exchange is obtained

$$R\left(q + \omega\frac{d}{dt}\right) v(\varphi) = \epsilon F(\varphi, \epsilon)\, v(\varphi) \qquad [2]$$

the solution of which is sought with the aid of the Krylov-Bogolyubov methods. An equation is derived by whose roots it is possible to decide the stability of the periodic solution. The theorem is then demonstrated of the analytical dependence of the solution of Eq. [2] on ϵ.

Yu. A. Mitropol'skii
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4296. Bradistilov, G., Position of a triple-mathematical pendulum in a plane with periodic and asymptotic motions around the position of equilibrium (in Russian), *Prikl. Mat. Mekh.* **19**, 4, 485–492, July/Aug. 1955.

4297. Chelpanov, I. B., Oscillations of a system with a relay of advancing characteristics, *J. Appl. Math. Mech. (Prikl. Math. Mekh.)* **22**, 1, 67–89, 1958. (Reprint order no. PMM 5, Pergamon Press, 122 E. 55th St., New York 22, N. Y.)

Consider a system with one degree of freedom governed by the equation

$$\ddot{u} + g(u, \dot{u}) + f(u) = -F(u)$$

where $F(u)$ is the characteristic of a relay with an insensitive zone (for $|u| < a$) and an advancing feature which operates, in part, as follows: As u increases from zero and attains the value a, the relay operates. If u reaches a maximum and then begins to decrease, the relay is disconnected at $u = a$ if $u_{max} < b$ and at $u = b$ if $u_{max} > b > a$.

Following a general discussion using phase plane and probabilistic considerations, as in statistical mechanics, the author concludes, primarily, that for the linear system the relay may effect stable behavior if the uncontrolled system is unstable, and, even if the system is stable, it may prove the dynamic behavior.

C. M. Crain, USA

4298. Faure, R., Synchronization of mechanical systems. On the simultaneous existence of two types of periodic solutions of nonlinear differential equations with periodic coefficients (in French), *C. R. Acad. Sci. Paris* **245**, 16, 1293–1295, Oct. 1957.

In this note the existence of two distinct types of periodic solutions of a system of nonlinear differential equations with periodic coefficients is shown. One of them is always of the same period as the forcing function; the other gives rise eventually to harmonic or hyperharmonic synchronizations. The latter type is then the only one existing.

From author's summary by H. D. Block, USA

4299. Faure, R., Synchonization of mechanical systems. Existence of two types of periodic solutions. About one case of confluence (in French), *C. R. Acad. Sci. Paris* **246**, 17, 2447–2449, Apr. 1958.

In this note there is exhibited a case of confluence of two types of periodic solutions arising in the synchronization of mechanical systems. This case is encountered in the Van der Pol method of approximation.

From author's summary by H. D. Block, USA

4300. Crossley, F. R. E., Non-linear vibrations in mechanical systems, *Engineering* **186**, 4823, 212–215, Aug. 1958.

4301. Tsukhanova, E. A., On the question of the analysis of piston motion in a hydraulic performance apparatus (in Russian), *Trudi Inst. Mashinoved., Akad. Nauk SSSR* **16**, 63, 17–40, 1956. (Translation by Morris D. Friedman, Inc., 67 Reservoir St., Needham Hts., Mass., T-132, 28 pp.)

Instrumentation and Automatic Control

(See also Revs. 4279, 4280, 4300, 4634, 3635, 4637, 4661)

4302. Koenig, L. A., The Bode diagram, an approach to regulating-system stability fundamentals, *Elect. Engng., Chicago* **78**, 6, 653–658, June 1959.

The difference between stable and unstable systems is demonstrated logically from the standpoint of the frequency-response diagram, often called a Bode diagram. In addition to providing a means of understanding fundamentals of regulating systems, the Bode diagram is a useful design tool.

From author's summary

4303. Vazaca, C., Forced and free, steady and transient state in automatic control systems (in Rumanian), *Automatica si Electronica* **2**, 5, 186–191, Sept.-Oct. 1958.

A series of theoretical considerations are presented, in order to make clear such notions as forced and free state, steady and transient state. The conclusion is drawn that the terms forced and steady, as well as the terms free and transient must not be considered synonymous. The conditions are shown in which a linear system may reproduce at the output, in steady state, the form of variation of the input quantity.

From author's summary

4304. Constantinescu, P., The evaluation of some quality indices by means of the Liapunov function (in Roumanian), *Automatica si Electronica* **2**, 4, 139–144, July/Aug. 1958.

Using the theorem of large stability, the evaluation of the quality indices $B(\delta)$ and $T(\delta, \epsilon)$ is given, by means of the Liapunov function. The results are applied for automatic control systems. Some examples are given by way of illustration. Ways for improving the evaluation of the quality indices are also considered. From author's summary

4305. Braslavskii, D. A., Computing the control time by means of the coefficients of the characteristic equation (in Russian), *Trudi Mosk. Aviats. In-ta* no. 75, 40–62, 1957; *Ref. Zh. Mekh.* no. 3, 1958, Rev. 2625.

It is shown, by means of examples, that the computation of control time for a linear system, carried out while taking into account only the material part of the poles of the transmitting function, appears to be very clumsy. Author proposes a method in which account is taken not only of the material but also of the simulated parts of the poles of the transmission function. A diagram is drawn for the determination of the control period by means of the coefficients of the characteristic equation for a system of the third order. E. N. Miroslavlev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4306. Pogosov, A. A., The graphical method of construction of transient processes in some dynamic systems (in Russian), Studies of the Moscow electrotechnical industry USSR on mechanisation and automation of the national economy, Vol. 2, Moscow, 1956, 154–169; *Ref. Zh. Mekh.* no. 11, 1957, Rev. 12410.

A method is described for the graphical integration of equations recording the transient processes in linear systems of automatic control. These methods appear to be modifications of the graphical constructions of transient processes known in the literature, and add nothing new in regard to systems with constant parameters, for which more effective methods for the construction of transient processes have already been worked out.

G. M. Ulanov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4307. Donegan, J. J., and Huss, C. R., Comparison of several methods for obtaining the time response of linear systems to either a unit impulse or arbitrary input from frequency-response data, *NACA Rep.* 1324, 13 pp., 1957.

See AMR **10** (1957), Rev. 388.

4308. Ankel, Th., and Hengst, K., How to improve the controllability of a system by introducing cascade control (in German), *Regelungstech.* **6**, 10, 361–366, 1958.

4309. Shen, C.-N., On the solution of a differential equation with nonlinearity appearing in the second derivative of combined linear and cubic terms, *Quart. Appl. Math.* **15**, 1, 11–30, Apr. 1957.

Paper indicates a solution describing the behavior of a system containing nonlinear capacity in a two-capacity process with linear feedback control. Solutions of a system of nonlinear differential equations is represented in the Y V-phase plane with different sets of graphs showing the effect of varying parameters; specific bounded and unbounded solutions, and general bounded solutions are obtained. Physical application is demonstrated on a nonlinear electric circuit with flux saturation.

Z. W.Dybczak, Canada

4310. Royle, J. K., Inherent non-linear effects in hydraulic control systems with inertia loading, Instn. Mech. Engrs., Prepr., 15 pp., 1958.

The paper considers the inherent nonlinear effects of inertia load on the performance of a pilot valve and ram system. Such a system may be considered as a model for many valve and ram or valve and motor combinations which are found in hydraulic control systems, and the results are therefore expressed in generalized form. It is shown that cavitation can occur dynamically when linear analysis would predict that only $1/2^{\frac{1}{2}}$ of the static stalled effort is being utilized. Prior to cavitation there is surprisingly little distortion and attenuation of the velocity wave form of the ram when the valve is moved sinusoidally. The beneficial effects of exhaust lap are discussed and the paper goes on to develop and qualify the analysis when compressibility, friction, leakage, symmetrical lap and dither are introduced. Experimental results are compared with the theoretical predictions and the paper includes a note on the validity of small-perturbation theory for this type of problem. From author's summary

4311. Schneeweiss, W., Nonlinear controllers in plants with higher order lags (in German), *Regelungstech.* **6**, 12, 437–442, 1958.

The influence of various nonlinear regulators for an integrating process with dead time is investigated. The transients obtained by a simple graphical method are interpreted by the describing function. From author's summary

4312. Herschel, R., and Kettel, E., The problem of scaling when using analog computers for the solution of automatic control problems (in German), *Regelungstech.* **6**, 11, 400–405, 1958.

When using analog computers for the solution of automatic control problems, the most essential supposition for the quantitative utilization of the solutions is suitable scaling and transformation of amplitudes and time. The difficulties arising in this connection are illustrated by an example of a differential equation and its block diagram. Some directions are given for scaling in the case of nonlinear problems. From authors' summary

4313. Ashkenas, I. L., and McRuer, D. T., Approximate airframe transfer functions and application to single sensor control systems, WADC TN 58-82 (ASTIA AD 151 025), 209 pp., June 1958.

Approximations to longitudinal and lateral rigid-body, level-flight airframe transfer-function factors are derived and presented in tabular form. These derivations are largely based on the use of a servo-analysis method which can be made exact. The approximate factors are shown to correspond to exact factors for certain simplified sets of the airframe equations of motion; and the physical implications of the correspondence are explored. The approximate transfer-function poles and zeros are related to fundamental stability and control quantities; and relative magnitudes for the poles and zeros of interesting transfer functions are established by an analysis of probable values for these quantities. The influence of airframe configuration changes on pole-zero arrangements is shown, and the effect of various arrangement possibilities on closed-loop operation is demonstrated using appropriate servo-analysis techniques. The results and methods used have direct application to the integrated design of airframe flight-control systems. From authors' summary

4314. Zhak, S. V., On the stability of some particular cases of motion of a symmetrical gyroscope containing liquid mass, *J. Appl. Math. Mech. (Prikl. Math. Mekh.)* **22**, 2, 330–337, 1958. (Reprint order no. PMM 27, Pergamon Press, 122 E. 55th St., New York 22, N. Y.)

A rigid symmetrical gyroscope containing an ellipsoidal cavity filled with an ideal incompressible fluid rotates under the action of gravity about a fixed point on the common axis of gyroscope and cavity. From general equations of motion derived from angular momentum, author obtains stability criteria for rotation about a

vertical axis in various special cases, including a spherical cavity and a thin massless shell.

The translation is outstandingly clear and readable.

L. Maunder, Scotland

4315. Lewis, C. W., Some factors influencing the speed of response of hydraulic position servomechanisms, *Aero. Res. Counc. Lond., Rep. Mem.* 3089, 13 pp., 1958.

Author treats a 4-way-valve positional servo of the type commonly used in guided-missile control-fin applications. The 4-way valve is positioned by an electric torque motor and the hydraulic reaction force (which tends to close the valve) serves as a hydraulic spring. The paper studies output oil flow through the valve as a function of current flow through the torque motor. The influence of the linkage configuration between the torque motor and valve is determined. Conditions for achieving a specified sensitivity are formulated. The paper should provide a useful design tool for missile and aircraft servo designers.

S. Z. Dushkes, USA

4316. Moncher, F. L., and Taylor, L. D., Current design practices in electro-hydraulic control systems for airborne aircraft and ground applications, ASME Design Engng. Conf., Chicago, Ill., Apr. 1958. Pap. 58-MD-6, 15 pp.

4317. Kryzhanovskii, O. M., and Timoshuk, V. V., Influence of the cable on the quality of the transition processes in a system of automatic control of a pilot shaft-lifting installation (in Russian), *Avtomatika Akad. Nauk URSR* **1**, 3–17, 1957; *Ref. Zh. Mekh.* no. 11, 1957, Rev. 13485.

Using the method of asymptotic resolution of the transcendental characteristic equations, the influence is investigated of a lifting cable (viewed as an elastic viscous thread) of constant length (when lifting from great depths the changes in length in the portion of evenly retarded movement may be disregarded) on the strength of the transition processes in a system of automatic control of a pit-shaft handling installation. A numerical example is examined (the case of lifting from great depths) for which relevant curves are furnished: for the speed of revolution of the drum and the speed of the skip in descent, for the skip's change of position relatively to the drum, and for the relative speed of the skip. Deductions are made from the data collected, regarding the influence of the cable, for both stable and unstable systems of control, on the natural motion of the machine (drum, engine).

G. N. Savin

Courtesy Referativnyi Zhurnal, USSR Translation, courtesy Ministry of Supply, England

4318. Tsai, D. H., and Slawsky, M. M., Determination and correlation of flow capacities of pneumatic components, *Nat. Bur. Stands. Circ.* no. 588, 7 pp., Oct. 1957.

Elasticity

(See also Revs. 4291, 4358, 4359, 4363, 4381, 4386, 4387, 4425, 4444, 4490, 4515, 4700, 4778, 4779)

4319. Nomura, Y., On the stiffening of edge of the hole in orthogonally aeolotropic plate with a circular hole (stiffened with the coaming plate), *Bull. JSME* **1**, 3, 199–204, Aug. 1958.

Paper treats problem of stress concentration around circular opening in an infinite rectangularly orthotropic plate subjected to uniform tension at infinity (the tension being parallel to one of the elastic axes). Edges of the opening are reinforced with a cylinder-like elastic isotropic ring. Effects of variation of stiffness properties of this ring on stress concentrations are illustrated in graphs and tables.

Reviewer considers paper routine and notes lack of an attempt to correlate results with known solutions of similar problems.

S. J. Medwadowski, USA

4320. Somov, N. I., Solution of the mixed static elasticity problem for an infinite strip (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 2, 136–138, Feb. 1958.

A solution is presented for an infinite strip with prescribed tractions at one boundary and prescribed displacements at the other. These boundary conditions are symmetrical. The specialized solution of the bi-Laplacian equation is obtained using Fourier integrals. The case when a uniform normal pressure acts on a part of one boundary and the displacements at the other boundary vanish is treated in detail. No numerical results are given.

This solution is useful in the approximate investigation of the splitting-off phenomenon in thick plates (plain strain problem) subjected to dynamic loading.

R. Schmidt, USA

4321. Choudhury, P., Stresses in an elastic layer with varying modulus of elasticity, *Bull. Calcutta Math. Soc.* **49**, 2, 99–104, June 1957.

Author considers two-dimensional elastic layer resting on a rigid foundation when Young's modulus varies exponentially with depth, the layer having a rectangular type of normal load over a finite portion of its upper surface. Numerical results are given for edge stress.

A. E. Green, England

4322. Malkin, I., The elastic problem of a homogeneous circular ring acted upon by equally spaced concentrated twists of equal magnitude (in English), *Ing.-Arch.* **26**, 3, 198–211, 1958.

The problem of an elastic circular ring acted upon by uniformly distributed twist has been treated by Grammel in 1923. The result is somehow a paradox: the ring loaded by twist is actually in bending, while the torsional stresses are zero; while the stresses produced in such a ring are thus virtually bending stresses, the bending deformation is zero. Grammel has also dealt with the case when the twist is not uniformly distributed but is concentrated on single points of equal distance, the twists being of equal magnitude.

Author carries on Grammel's investigations and obtains the following results. Under the assumption of small initial curvature and small deformations, especially small twist angles, and with some reservations, a homogeneous circular ring acted upon by equally spaced concentrated twists of equal magnitude is always free of torques. The bending moment, represented by a vector normal to the original plane of the ring, vanishes if one of the two cross-sectional principal axes is situated in the plane just mentioned. Otherwise this bending moment differs from zero.

F. Chmelka, Austria

4323. Ionov, V. N., Equilibrium of an elastic cylinder of finite length (in Russian), Investigations on the theory of constructions no. 7, Moscow, Gosstroiizdat, 1957, 413–436; *Ref. Zh. Mekh.* no. 3, 1958, Rev. 3133.

The problem is examined of the elastic equilibrium of a tapered cylinder of finite length. Following the method of M. M. Filonenko-Borodich [*Prikl. Mat. Mekh.* **15**, no. 2, 1951], author evolves a stress tensor from three tensors: the initial, the supplementary and the correcting. The components of the initial tensor have to satisfy the equations of equilibrium in the absence of spatial forces and the given boundary conditions on the cylinder's surface; some special cases of surface loading are examined: (1) normal terminal forces, (2) tangential terminal forces, (3) internal and external pressure. The supplementary stress tensor is found to be a special solution of the equilibrium equation, which leaves the cylinder's surface free from stresses; a supplementary tensor is devised for a centrifugal force and for a gravitational one. The

correcting tensor satisfies the homogeneous boundary conditions on the cylinder's surface and contains, in addition, a series of arbitrary constants, determinable from the condition of minimum potential energy (the equations of joint deformation are not satisfied by the proposed solution). It is proposed to set up the correcting tensor in the form of triple series of derivatives of cosine binomials and the usual trigonometric functions of variables r, θ, z.

V. K. Prokopov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4324. Mossakovskii, V. I., Pressure of a circular die (punch) on an elastic half-space, whose modulus of elasticity is an exponential function of depth, *J. Appl. Math. Mech. (Prikl. Mat. Mekh.)* **22,** 1, 168–171, 1958. (Reprint order no. PMM 11, Pergamon Press, 122 E. 55th St., New York 22, N. Y.)

Author claims to have discovered inaccuracies in a paper by B. G. Korenev giving the solution to the title problem [AMR **11** (1958), Rev. 4886]. The solution presented is better suited for practical calculations.

F. Ellis, England

4325. Ugodchikov, A. G., Calculations for cavitation stresses in some types of pressed unions (in Russian), *Trudi Gor'kovsk. Inzh.-Stroit. In-ta* no. 25, 28–43, 1956; *Ref. Zh. Mekh.* no. 11, 1957, Rev. 13505.

Cavitation stresses are determined by the methods of the plane theory of elasticity; the works of D. I. Sherman [*Dokladi Akad. Nauk SSSR* **27,** no. 9, 1940] are made use of. It is assumed that the pressed components appear as round, continuous plates and that the tension of the pressing is constant round these plates. The external contours of the components are chosen in the form of curves, possessing the same property as the region's; bounded by these curves, it is possible with the help of a polynomial of degree n to produce a conforming reflection to the circle of the unit radius. In this case the problem merges with the solution of a system of linear equations. Results of numerical calculations are given. Approximate formulas are put forward.

L. I. Balabukh

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4326. Sesan, A., General static relations for the study of bending (in French), *Bul. Inst. Politehnic Iasi* **8,** 1/2, 407–414, 1958.

Proceeding from the remark that the deflection, the rotation, the bending moment, the shear force and the uniformly distributed load (δ; M; T; p) which are called bending functions, satisfy the known differential relation

$$|\delta;\ M;\ T;\ p| = \left\{ \pm\frac{dy}{dx};\ \pm EI\frac{d^2y}{dx^2};\ \pm EI\frac{d^3y}{dx^3};\ \mp EI\frac{d^4y}{dx^4} \right\}$$

and that the general solution of equations $\dfrac{d^m y}{dx^m} = y(x)$ is

$$y = \frac{1}{(m-1)!}\int_{x_0}^{x} (x-t)^{m-1}\,\varphi(t)dt + \sum_{p=1}^{m} \frac{C_p\,\chi^{m-p}}{(m-1)!}$$

author shows that the first relation may be set under the form

$$|y,\ \delta,\ M,\ T,\ p| = |M_\rho^{IV},\ M_\rho''',\ M_\rho'',\ M',\ M^0,\ M^{-1}|$$

where the functions in the right band side are called "factorial moments." The relation which exists between these two moments of different orders is also given.

By means of the factorial moments, any of the bending functions can be calculated. The method represents in fact an extension of Mohr's moment-area method.

R. Priscu, Roumania

4327. Chatterjee, B. B., Stresses in a dumbbell-shaped disk rotating about an axis lying in its middle plane, *J. Appl. Mech.* **25,** 2, 290–292 (Brief Notes), June 1958.

Book—4328. Gatewood, B. E., Thermal stresses, New York, McGraw-Hill Book Co., Inc. (Publications in Aeronautical Science), 1957, xv + 232 pp. $7.50.

Book contains methods of attack for a variety of thermal stress problems, including those pertaining to elastic and inelastic thermal stresses in structures, and allowable stresses for various materials and loadings. Methods are presented for dealing with structural design problems relating to the effects of elevated temperatures on the buckling, deflection, stiffness, fatigue, shock, and flutter characteristics of structural systems or components. Attention is focused mainly on those elevated temperature problems associated with aircraft and missile structures, jet engines and nuclear reactors.

Author believes that the many simplifying assumptions made throughout the book are consistent with the overall accuracy of the basic assumptions and data used by most designers, and he places little emphasis on the more refined analytical methods which, in general, require analog or digital computers.

The book contains illustrative examples and exercise problems, in addition to a rather complete compilation of the pertinent references in the field. The text is therefore particularly suited to both the student and structural designer.

M. M. Lemcoe, USA

4329. Correlation of thermal stresses in circular cylinders and flat plates, *Engineer, Lond.* **207,** 5372, 56–57, Jan. 1959.

Numerical results are presented for thermal transient stresses in hollow cylinders, lagged on the inner face, due to a step change in fluid temperature. Calculations published by other authors are replotted on a common basis to display the connection between them. Further calculations have been made where necessary.

From summary

4330. Boley, B. A., and Barrekette, E. S., Thermal stress in curved beams, *J. Aero/Space Sci.* **25,** 10, 627–630, 643, Oct. 1958.

Thermoelastic stresses are investigated in curved beams of constant properties and constant cross section under temperatures varying in the radial direction only. Good agreement is found between stresses as calculated from elasticity theory and from strength-of-materials theory which assumes that plane sections remain plane. A comparison with the corresponding straight-beam formula is also included.

From authors' summary by M. J. P. Musgrave, England

4331. Kaufmann, W. J., Preheating of pipelines for steam (in German), *Brennstoff-Warme-Kraft* **10,** 9, 428–433, Sept. 1958.

In large steam power-generating stations condensation often occurs when pipelines are being filled with steam. Due to the high heat-transfer rate during condensation the transient conditions are similar to a thermal shock. Using known results for unsteady temperature distributions in plates and simple stress formulas, the thermal stresses are calculated which occur when steam condenses in cold tubes. The highest permissible steam pressures are given when plastic deformations due to thermal stresses in pipes are to be avoided. Methods are discussed for preheating pipes either continuously or in steps in such a way that no danger for permanent deformations exists.

H. Schuh, Sweden

4332. Chen, S.-Y., Transient temperature distribution and thermal stresses in a hypersonic unsymmetrical wing structure at angles of attack, ASME Semiann. Meet., Detroit, Mich., June 1958. Pap. 58-SA-63, 26 pp.

The effects of structural asymmetry (through the depth) and of differences in adiabatic wall temperatures and heat-transfer coefficients on the upper and lower wing surfaces are analyzed. An idealized skin-flange-web configuration is treated by Laplace-transform techniques to obtain the transient temperature and thermal-stress distributions in the structures.

Paper is replete with equations but no sample numerical results are presented. J. M. Hedgepeth, USA

4333. Podstrigach, Ya. S., and Plyatsko, G. V., Influence of heat emission on the thermal stresses in an elastic strip when an unsteady thermal regime is operating (in Russian), *Nauch. Zap. In-ta Mashinoved. Avtomatika Akad. Nauk USSR* **6**, 75–82, 1957; *Ref. Zh. Mekh.* no. 3, 1958, Rev. 3146.

The solution of a problem in heat conductivity is given for an infinite strip in which the temperature of the lower side changes at a constant velocity, the lateral sides find themselves in conditions of thermal isolation, while in the upper side heat emission is proceeding into a medium of constant temperature; this solution contains a series of functions depending on the roots μ_n of the transcendental equation $tg\mu l = -\mu/b$, where l is the thickness of the strip, b the relative coefficient of heat exchange. For the indicated thermal field, a solution is given, furthermore, for the problem of the thermoelastic equilibrium of the infinite strip, the sides of which are free from external forces; the boundary conditions on the upper and lower sides of the strips are precisely fulfilled, those for the lateral sides in the sense of Saint-Venant's principle. Notwithstanding the fact that the thermal field is nonstationary, authors disregard the inertia forces when examining the quasi-statical problem. The stresses obtained (as also the temperatures) are proportional to the heating rate. In conditions of ideal heat isolation ($b = 0$) the stresses from a certain moment become practically constant. The maximum stress values are reached on the heated side. V. K. Prokopov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4334. Timo, D. P., and Parent, D. F., Thermal distortion of turbine rotors, ASME Ann. Meet., New York, N. Y., Nov./Dec. 1958. Pap. 58-A-270, 9 pp.

4335. Sharma, B., Thermal stresses in transversely isotropic semi-infinite elastic solids, *J. Appl. Mech.* **25**, 1, 86–88, Mar. 1958.

See AMR **11** (1958), Rev. 3474.

4336. Suncheleev, R. Ya., Solution of contact problems in the theory of elasticity for a homogeneous anisotropic body with an axis of symmetry of infinite order (in Russian), *Nauch. Zap. L'vovsk. Politekhn. In-ta* 1956 (1957), no. 38, 53–65; *Ref. Zh. Mekh.* no. 3, 1958, Rev. 3131.

The system of equations of equilibrium of an elastic homogeneous transversally-isotropic body in projection transfer is recorded in its matrix form in the form of one equation. Making use everywhere of the matrix symbolic expression, author converts this system, introducing new independent variables y_1, y_2, t_1 and functions w_1, w_2, w_3, linked with the initial linear relations and also the polar coordinates r, φ. Then solutions are evolved for the first and second basic problems of the theory of elasticity for a transverse-isotropic semispace with the aid of series having the form of

$$w = \sum_{-\infty}^{\infty} e^{ik\varphi} \int_0^{\infty} I_{Ek} + C_1^{(\lambda r)} X^{(k)}(\lambda, y_3) d\lambda \qquad [1]$$

These solutions were obtained in previously published work of the author but for a more general case of a heterogeneous semispace [*Nauch. Zap. L'vovsk. Politekhn. In-ta* no. 30, 3–14, 1955]. The same series offer the possibility of deriving a solution of the mixed problem—on the pressure of a round die, applied to the restricting surface. The last problem ultimately merges with the integral equations of the type

$$M\int_0^{\infty} f(\lambda)\, I_\nu(\lambda r)\, d\lambda = g(r) \quad \text{for } r < 1$$

$$L\int_0^{\infty} \lambda f(\lambda) I_\nu(\lambda r)\, d\lambda = 0 \quad \text{for } r > 1 \qquad [2]$$

where L, M are constants, gI_ν are known functions, while $f(\lambda)$ is an unknown function; the solutions of these equations are capable of being recorded in a clear form. The problems here investigated were solved earlier in a different way [see, for instance, Khu Khai-chan, *Uli syuebao* **10**, 3, 239–258, 1954].

S. G. Lekhnitskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4337. Manea, V., and Procopovici, E., An extension of the torsion problem for turbine blades (in Roumanian), *Studii si Cercetari Mecan. Appl.* **10**, 1, 203–209, 1959.

Paper concerns torsion problems for hydrodynamic profiles obtained through the succesive conformal mappings $Z_1 = [(1 + \zeta)/2]^r$, $Z = (Z_1 - Z_1)^m$, m being an integer > 1. The case $m = 2$ is explicitly treated. D. Gh. Ionescu, Roumania

4338. Chattarji, P. P., Torsion of a circular cylinder having a rigid spherical inclusion, *Bull. Calcutta Math. Soc.* **49**, 4, 199–205, Dec. 1957.

Author makes novel approach to problem using differential equation for angular rotation ϕ of elemental ring, radius r, of compound cylinder instead of usual stress function for torsion. In this way conditions reduce to $\partial\phi/\partial r = 0$ on external surface and $\phi = 0$ on surface of inclusion. Expression of equation in terms of cylindrical and spherical co-ordinates leads, respectively, to the Bessel and Legendre equations. Reviewer suggests that Legendre equation [14] in the paper is wrongly expressed in that $d^2G/d^2$2 and dG/de should be replaced by d^2G/d^2w and dG/dw. However, author's subsequent analysis is not affected by change.

Author considers solution $\phi = \phi_0 + \phi_1$ where ϕ_0 relates to normal cylinder without inclusion and ϕ_1 represents modification due to inclusion. ϕ_1 is expressed as sum of Bessel and Legendre solutions. With known results for unknowns in these solutions author develops series for ϕ involving parametric coefficients of general term A_{2n}. The validity of series depends on convergence of A_{2n}. Author illustrates convergence for values of $\lambda = 1/6$, $1/3$ and $1/2$ (λ = radius inclusion/radius of cylinder), and says that convergence exists if $\lambda < 1$. Reviewer doubts practical importance for $\lambda > 0.75$. Author then develops simple expression involving A_2 of effect of inclusion on angle of twist. Based on his values of A_2, reductions of 0.06, 2.16 and 15.12% obtain for a cylinder of unit radius with $\lambda = 1/6$, $1/3$ and $1/2$, respectively. Author also gives table showing variation of shear stress over section for various values of λ and compares with variation of shear stress for $\lambda = 0$. As expected, maximum values decrease with increase in λ. For example, a 16% reduction obtains for $\lambda = 1/2$.

Author is to be congratulated on intelligent and concise assessment of advanced problem. G. Little, England

4339. Boudarenko, B. A., Application of the alternating method to the solution of the problem on the torsion of a prismatic rod of I-section (in Russian), *Trudi In-ta Matem. i Mekhan. Akad. Nauk UzSSR* no. 18, 43–51, 1956; *Ref. Zh. Mekh.* no. 3, 1958, Rev. 3158.

The problem is solved regarding the torsion of a prismatic rod of I-section by Schwartz's alternating method for the solution of Dirichlet's problem for harmonic functions, for the case when the region of transverse section is the sum of two (according to the theory of numbers) regions; in the set case, two rectangles. The recurrence formulas are given for the calculation of Fourier's coefficients, entering the expression of the functions of torsion for one rectangle through Fourier's coefficients, from the expression of the functions of torsion for the other rectangle. The coefficients $\delta_k^{(0)}$, A_k, $\eta_s^{(1)}$, $\eta_s^{(2)}$, L_s are incorrectly calculated.

N. O. Gulkanyan

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4340. Leonov, M. Ya., Leading to the elementary theory of torsion (in Russian), *Nauch. Zap. In-ta Mashinoved. i Avtomatiki, Akad. Nauk USSR* **6**, 109–119, 1957; *Ref. Zh. Mekh.* no. 3, 1958, Rev. 3156.

An approximate solution is put forward for the problem of the free torsion of elastic rods of constant continuous section. An investigation is made of the orthogonal network of the trajectories of stresses and of the lines normal to them, intersecting at a joint accepted as the center of rotation. The full tangential stress at the points in the transverse section is determined by the formula $\tau = 2\,G\theta\,(dw/dn)$. Here G is shear modulus, the relative torsional angle, dw the plane of the curvilinear triangle, formed by the two normal lines and the cutting dn of the trajectory passing through the point under observation. For the determination of the position of the joint the theory is made use of, by means of which the flow of tangential stresses across an arbitrary normal line, going from the joint to the contour, is a constant, independent of the selection of normal lines. The results obtained enable a determination to be made of the stresses in the points of the normal lines, known as regards position. The stress values are given on the axes of symmetry of the sections, which have the form of an incomplete round ring, of a regular polygon and of a rectangle. The precision of the results depends on the successful selection of normal lines, close to the axis of symmetry. Two principles of "localization" are enunciated, with the aid of which, knowing the solution of the problem of torsion for one rod, it is sometimes possible to determine the stresses in another rod.

K. V. Solyanik-Krassa

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4341. Chattarji, P. P., Twisting of a hollow circular cylinder of cylindrically aeolotropic material with outer surface fixed and inner surface acted on by tangential tractions, *Indian J. Theor. Phys.* **4**, 3, 59–64, Sept. 1956.

Title problem is solved using product-type solutions of displacement equilibrium equation in conjunction with Fourier series expansion of tractions on inner boundary. Explicit results are given for case of tractions uniformly distributed over part of inner boundary.

K. S. Pister, USA

4342. Carter, W. J., Torsion and flexure of slender solid sections, *J. Appl. Mech.* **25**, 1, 115–121, Mar. 1958.

See AMR **11**(1958), Rev. 2056.

4343. Csonka, P., Generalization of Saint Venant's theory of pure torsion (in Hungarian), *Magyar Tud. Akad. Musz. Tud. Oszt. Közl.* **22**, 1/3, 77–78, 1958.

Viscoelasticity

(See also Revs. 4367, 4526)

Book—4344. Finnie, I., and Heller, W. R., Creep of engineering materials, New York, McGraw-Hill Book Co., Inc., 1959, ix + 341 pp. $11.50.

A timely book on a subject not adequately treated elsewhere. Authors attempt to present current state of knowledge of creep and design for conditions where creep is expected. They have succeeded very well in treating this complex and rapidly expanding subject in a readable and well-organized fashion. As is natural for a book on a rapidly developing topic the volume is not entirely up to date. Abundant references (but by no means exhaustive) are generally well chosen. The few critical evaluations of contemporary work which are included are not always the most discerning. One might wish the authors had made a more complete use of the references by stating the source of all the important observations and opinions—especially those presented in brief.

The topics covered include: One third on mechanisms of creep of metals, plastics and other non-metals, creep behavior of specific metals; one third on stress analysis and theories of flow for uniaxial and multiaxial stresses under steady-state and transient creep, with applications such as thick-walled tubes, rotating disks and buckling; and one third on presentation of data, choice of design stress and applications in such fields as chemical plants, steam, gas turbine and nuclear power plants, concrete and geology.

Sections on stress analysis are well presented, although the reader who lacks a substantial background in this area may need to consult the references for details. Presentation of viscoelastic theory and the superposition principle are somewhat sketchy. The available data supporting the usual assumptions employed for theories of creep under combined stresses are neither shown nor cited as references.

W. N. Findley, USA

4345. Oding, I. A., and Ivanova, V. S., A generalized diagram of the criteria of creep, making use of new relations between the stresses, the creep velocity and the service life of the metal (in Russian), Investigations on heat-resistant alloys, Moscow, Akad. Nauk SSSR, 1956, 52–59; *Ref. Zh. Mekh.* no. 11, 1957, Rev. 13182.

For the purpose of presenting results of experiments on creep and prolonged endurance, the proposal is put forward to use a generalized diagram, constructed in the following way: In the positive direction of the abscissae axis is set off the logarithm of the deformation velocity, while in the negative, the logarithm of time; in the positive direction of the ordinates axis is set off the stress, while in the negative, the logarithm of the creep resource $\varepsilon_r = v\tau$, where v is the creep velocity and τ is the service life. Some ideas are given on the advantages of bringing in the creep resource. It is established that the exponential relationships between the creep velocity and stresses and between the stresses and the service life describe the experiment better than the step-by-step procedure.

V. S. Namestnikov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4346. Namestnikov, V. S., On creep under constant loads for condition of multiaxial state of stress (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 4, 141–146, Apr. 1957.

The results of creep tests on austenitic sheet are presented. Specimens were subjected to simultaneous tension (σ) and torsion (τ). The tests were carried out for different ratios of τ to σ. Author shows that a general relation: $f(\rho_i, \dot{\rho}_i, \sigma_i)$, and a corresponding relation: $\rho_i \dot{\rho}_i^{\alpha} = K \exp \sigma_i / A$, where $\rho_i = (\varepsilon^2 + \frac{1}{4}\gamma^2)^{1/2}$ and $\sigma_i = (\sigma^2 + 3\tau^2)^{1/2}$, are in disagreement with the experimental results.

He proposes a new relation of the form: $\dot{\rho}\rho_i^{\alpha} = \chi \exp\left(\frac{\sigma_i}{A} - \frac{|\tau_{max}|}{A_0}\right)$, in which shear stress τ appears explicitly.

In reviewer's opinion, author presents very interesting data of creep for the case of complex stress conditions. His conclusions concerning the relationship between generalized strain, rate of straining and stress, which is essentially "equation of state," are in agreement with many authors who have investigated this problem [Kochendörfer, *Z. Kristallographie* **97**, p. 263, 1937; Orowan, *J. West of Scotland Iron and Steel Inst.* **54**, p. 45, 1947; Dorn, Goldberg and Tietz, *A.I.M.E. Trans.* **180**, p. 205, 1949; etc.]. The relation proposed by author, which conforms reasonably well with the data presented in the paper, in the reviewer's opinion,cannot be considered as a general one for the same reasons that invalidate an equation of state. W. D. Sylwestrowicz, USA

4347. Rabotnov, Yu. N., On some possibilities of describing nonsteady creep with application to the study of rotor creep (in Russian), *Izv. Akad. Nauk SSSR Otd. Tekh. Nauk* no. 5, 30–41, May 1957.

As a basis for his evaluations, author accepts the "equation of state" $F(\rho, \dot{\rho}, \sigma, T) = 0$, and its specific form

$$\dot{\rho}\,\rho^{\alpha} = K \exp(|\sigma|/A), \text{ where } \rho = |\varepsilon - \sigma/E|$$

After considering the uniaxial stress condition, the case of the complex stress system is discussed. A short discussion is also given on the influence of the rate of loading. Finally, author applies the relations obtained to specific problems connected with creep in turbines at high temperature.

In reviewer's opinion, the "equation of state," on which the theoretical part of this paper is based, is basically incorrect and also the specific form used by the author. This was demonstrated by the work of Namestrikov [see preceding review]. Despite these reservations, this work can be of help in the evaluation of elements working at high temperatures.

W. D. Sylwestrowicz, USA

4348. Goodey, W. J., Creep deflexion and stress distribution in a beam—analysis for a rectangular beam subjected to a constant bending moment, *Aircr. Engng.* **30**, 352, 170–172, June 1958.

4349. Sanders, J. L., Jr., McComb, H. G., Jr., and Schlechte, F. R., A variational theorem for creep with applications to plates and columns, *NACA Rep.* 1342, 7 pp., 1958.

See AMR **10** (1957), Rev. 3956.

4350. Mirkin, I. L., and Trunin, I. I., Investigation of creep and the failure of steel in the stress concentration zone (in Russian), Tests on and properties of heat-resistant materials, Moscow, Mashgiz, 1957, 25–45; *Ref. Zh. Mekh.* no. 11, 1957, Rev. 13571.

Tests are described for creep and prolonged resistance of cylindrical test samples with ring-shaped notching, made of thermally treated steels EI257 and EI10 in the temperature range of 550–650°. By determining the increment of microhardness in different points of the longitudinal section, authors were able to ascertain approximately the zone of maximum plastic deformation. For the purpose of analysis of the failure process the technique of layer-by-layer section study of the micro-structure was adopted. Within the experimental conditions a number of peculiarities were observed and established at room temperature: the sharply expressed irregularity of stress distribution and of plastic deformation of the metal below the notching; the maximum deformation in the adjacent and surface layers of metal at the bottom of the notching. With recession from the surface layers to the center the degree of deformation drops sharply. The starting foci of failure lie at a depth of 0.2–0.4 mm from the bottom of the notching. The peak of axial stresses lies near the bottom of the notching in the place of the first focus of failure. At this point a deduction is made that the paramount stress in failure appears to be the normal stress. Under the influence of relaxation the stress peaks with the passage of time even out to some extent. Failure always took place along the boundaries of the grains.

V. S. Pamestnikov
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4351. Shkorbelis, K. K., Influence of vibration on the creep of ferroconcrete structures (in Russian), Questions in dynamics and dynamic stability, no. 4, Riga, Akad. Nauk LatvSSR, 1956, 27–35; *Ref. Zh. Mekh.* no. 11, 1957, Rev. 13429.

The experiments made by the author are described; points established are (1) that, with simultaneous action of static and vibration loads on ferroconcrete structures, the principle of superposition for the determination of the deformation of creep is inapplicable; (2) that vibrations may strongly increase the deformation of creep. It is assumed that the influence of vibration reactions may be taken into account approximately by the coefficient of vibrocreep, linked linearly with the amplitude and vibration frequency. N. P. Kashparova
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4352. Harris, G. T., Child, H. C., Collier, A. B., and West, C. F., Recent developments in creep testing by the cantilever bending method, *J. Iron Steel Inst. Lond.* **190**, 2, 136–143, Oct. 1958.

Cantilever creep units of high strain sensitivity are described. These are capable of carrying out tests at temperatures up to 1200 C, at stresses of from 50 lb/in.^{2} to 50 tons/in.^{2} with a sensitivity of strain measurement of from 1 to 3×10^{-6}. Several suitable applications of these units are exemplified. These include alloy development where the stress for low creep strains is the criterion, tests on precision castings, "micro-specimens," unmachinable materials, sheet, tests above 1000 C, and tests in vacuo or in inert atmospheres. It is shown that satisfactory correlation of cantilever creep data with tensile data is possible.

From authors' summary by F. K. G. Odqvist, Sweden

4353. Glen, J., The effect of alloying elements on creep behavior, *J. Iron Steel Inst. Lond.* **190**, 2, 114–135, Oct. 1958.

Evidence is presented to show that, unlike pure metal or simple solid solutions, the creep resistance of most alloys depends on various strain-age-hardening or strain-induced precipitation phenomena. Each of these effects results in what has been termed a transition in creep rate, i.e. a sudden deceleration in creep rate over an interval of time. A simple theory has been developed to explain these transitions in creep rate and to show the effect of the stress and temperature of testing. Proof of this theory is given by the results of many creep tests on steel. The effects of N, C, Mn, Cr, Mo, V, Ti, and Si as alloying elements are considered in some detail. The results of creep tests on austenitic alloys and Ti alloys are also given to show that transitions in creep rate are of common occurence in most commercial alloys. Eq. [2] contains several obvious misprints.

From author's summary by F. K. G. Odqvist, Sweden

4354. Glen, J., A new approach to the problem of creep, *J. Iron Steel Inst. Lond.* **189**, 4, 333–343, Aug. 1958.

A number of strain-age-hardening phenomena were observed in high-temperature tensile tests, each being associated with the presence of a particular alloying element. It has now been found that related effects can be detected in the creep curves of various steels and other alloys. These take the form of a sudden deceleration of creep rate over an interval of time and have been called transitions in creep rate. Several transitions usually occur in the creep curves of commercial alloys. To show these transitions in

creep rate in their true perspective it was found necessary to plot creep data in the form of log strain/log creep-rate curves (strain/rate curves). A family of such curves either at constant stress or at constant temperature forms a regular pattern so that the strain/rate curves of tests at lower stress or temperature can be estimated. By integration the ordinary strain/time creep curves are obtained. In this way accurate extrapolation of creep or rupture tests can be carried out. The results of tests on several manganese steels were used to illustrate the above phenomena.

Reviewer considers it important to emphasize that author's extrapolation of "strain/rate" curves is based on assumption of an equation of state between strain rate and strain for constant stress or temperature and thus excludes, e.g., independent time influence on strain rate.

From author's summary by F. K. G. Odqvist, Sweden

4355. Stowell, E. Z., A phenomenological relation between stress, strain rate, and temperature for metals at elevated temperatures, *NACA Rep.* 1343, 6 pp., 1958.

See AMR **10** (1957), Rev. 3631.

4356. Paslay, P. R., Calendering of a viscoelastic material, *J. Appl. Mech.* **24,** 4, 602–608, Dec. 1957.

See AMR **11** (1958), Rev. 880.

4357. Panshin, B. I., and Finogenov, G. N., Machine for testing plastic materials for repeated static loading (in Russian), *Zavod. Lab.* **22,** 11, 1353–1364, 1956; *Ref. Zh. Mekh.* no. 11, 1957, Rev. 13646.

The reconstructed machine VP-8 is described; it is designed for testing samples for prolonged endurance and creep. After reconstruction the machine can be used for fatigue tests on samples of metal, wood and other materials. The apparatus is not suitable for testing materials with a low modulus of elasticity (types of rubber). The dimensional limits of plastic materials samples are recorded, and a procedure is described enabling tests to be carried out on several (from 2 to 6) samples simultaneously.

N. G. Kushelev

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

4358. Mellgren, A., Measuring accuracy in creep tests. II. Influence of thermal stresses (in English), *Instn. Hallfasthetslara, KTH Publ.* no. 126, 43 pp., 1958.

Author claims creep rate is influenced apparently by fluctuations in temperature. Elastic solutions for a circular cylinder and for a plate subjected to periodically varying temperature distributions on the surface are presented. Assuming strain rate as a linear combination of elastic terms and a second-stage creep term following Norton's law, author analyzes cylindrical and thin plate specimens. Author concludes that the small thermal stresses caused by the temperature variation do not appreciably affect the creep limit. Reviewer believes that lack of notations list leads to some confusion. R. E. Miller, USA

Plasticity

(See also Revs. 4352, 4353, 4354, 4355, 4410, 4413, 4459, 4494, 4526)

4359. Krylov, A. L., Axially symmetrical plane elasticofriable problem of the propagation of the equilibrium limit, *Soviet Phys.-Doklady* **3,** 1, 199–200, Dec. 1958. (Translation of *Dokladi Akad. Nauk SSSR (N.S.)* **118,** 5, 882–883, Jan.-Feb. 1958 by Amer. Inst. Phys., New York, N. Y.)

The problem treated is primarily of academic interest. The behavior of the medium considered for small stresses is described by the equations of linear elasticity, and for large values of the stresses acquires friable properties. The case of plane deformed state of a model filling the region outside the unit circle is treated.

Author's hypothesis—that conservation of incompressibility requires coincidence of one direction of maximum strain rate with the direction of the slip lines which form the smallest angle with the boundary on the contour—is used. By application of this criterion it is shown that the problem without rotation is unstable and that the resulting motion in presence of a small rotation greatly differs from pure expansion. A. Slibar, Germany

4360. Onat, E. T., Analysis of shells of revolution composed of workhardening material, *J. Mech. Phys. Solids* **7,** 1, 45–59, Nov. 1958.

Paper deals with the derivation of the yield surface for thin shells of work-hardening material. It is first shown that the generalized stresses, the membrane forces and bending moments, are given by the corresponding partial derivatives of the rate of energy dissipation with respect to principal extensions and curvatures. The dissipation function is taken as the integral over the thickness of the product of yield stress and maximum strain rate. Evaluation of the integrals gives part of the yield surface in the parametric form. Cases arising from different distributions of strain rates are discussed. From these the stress and strain rate relations are obtained. Two types of material are discussed: one exhibiting isotropic hardening and the other showing Bauschinger effect. These are distinguished by their dependence on strain history. Discussing the case of a cylindrical shell the laws for both types are illustrated. Finally, the case of a cylindrical shell under uniform pressure is treated with emphasis on the discussion of uniqueness. G. A. Nariboli, India

4361. Boyce, W. E., A plane stress problem in piecewise linear plasticity, AFOSR TN 58–629 (Rensselaer Polytech. Inst., Dept. Math. no. 16; ASTIA AD 162 159), 24 pp., Aug. 1958.

Certain plane stress problems in piecewise linear strain-hardening plasticity can be considered either directly on the basis of a two-dimensional model, or as a special case of a more general theory. Isotropic theories yield the same results regardless of which approach is adopted, but anisotropic theories, such as those using Prager's kinematic hardening law, may not. This paper treats a specific plane stress problem, the bending of a rigid-plastic simply-supported circular plate by a uniform load, from a three-dimensional point of view, using Prager's hardening law. This more elaborate theory predicts displacements less than half as large as those obtained for the same loads from the two-dimensional theory. The dependence of the post-yield stresses and displacements on the magnitude of the initial yield stress is also examined. From author's summary

4362. Drapkin, L. G., Application of the properties of lines of displaced layers during the plastic deformation of multi-layer metals for the engineering calculations of stresses and forces (in Russian), *Trudi Leningrad Voen.-Mekhan. In-ta* no. 5, 41–54, 1956; *Ref. Zh. Mekh.* no. 3, 1958, Rev. 3251.

A method is proposed for the use of laminated metal for the investigation of the stress-deformation state and forces appearing during pressure-treatment of metals. Formulations are put forward for the properties of lines of displaced layers of the laminated metal. The procedure is indicated for the calculations of stresses at points in the deformed body, composed of multi-laminar metal, with the aid of the lines of displaced layers. A theoretical justification of the method is given. A. D. Pospelov

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

4363. Ershov, L. V., and Ivlev, D. D., Elasto-plastic state of an elliptic tube subjected to internal pressure (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 9, 130–134, Sept. 1957.

Authors investigate the elasto-plastic stresses and deformations in a pipe with a cross section of small ellipticity subjected to internal pressure p. At the same time the problem of losses in the carrying capacity of the pipe under consideration is studied. The solution begins with the consideration of a point where the stress is known in a pipe of circular cross section under internal pressure p, and of small deformation, and linear between the internal and external surfaces of the pipe. By introducing a stress function it is possible to write a differential equation which can be solved by existing methods (separation of variables), and the constants of integration determined from the end conditions. The deformations are established relative to the internal radii of the pipe.

M. Maletz, USA

4364. Csonka, P., Calculation of initial stresses of rolled high pressure vessels (in Hungarian), *Magyar Tud. Akad. Musz. Tud. Oszt. Közl.* **21**, 1/4, 67–74, 1957.

4365. Zhukov, A. M., Plastic deformations of an isotropic metal under complex loading (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekhn. Nauk* no. 12, 72–87, 1956; *Ref. Zh. Mekh.* no. 11, 1957, Rev. 13144.

A survey is given of experimental investigations of plastic deformations under complex loading. Author concludes that the existing theory of plasticity is in agreement with experiment and under the action of complex loading, differing from simple loading if the orientation of the axes of the stresses tensor is conserved, and is not in agreement with the experiment, even with small departures from simple loading, if the last is accompanied by a sharp turn of the axes of the stresses tensor. A negative point of view is expressed in regard to the existance of angles on the trajectory of flow (on the boundary of elastic conditions). Further, the results are put forward of tests carried out by the author on steel 30 KhNZA during the complex loading when operating under bi-axial tension (created in the walls of annular test samples). The amplitude of stress intensity either increased or remained constant at certain stages of the test. When testing parts of the samples there was a significant decrease in one of the tensional stresses. The appearance of the first plastic deformations in the material was in satisfactory agreement with Huber-Mizes' conditions. The curves, linking the intensity of deformation and stress, were close to each other, diverging, as regards intensity of stresses, within the limits of ±5% from its mean value. In addition to this, the difference observed in plastic deformations up to disruption was considerable. A noticeable increase in plastic deformation was seen when loading with conservation of the constancy of stress intensity. The tests did not disclose the influence of systems of thermal treatment on plastic deformation, though these showed a large influence on the impact viscosity of the material. Data were given for the observed declinations from the equality of Lode's parameters. In conditions of complex loading these divergences became more significant. Comparison of the experimental results with calculations by means of the theory of small elastic-plastic deformations led author to the deduction that for investigation of cases of complex loading this theory does not give significant divergences from the actual. The stage of disruption, independent of the course of loading, is characterized by approximate constancy of the maximum tension stress.

Yu. I. Yagn

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4366. Zaslavskii, B. V., Plastic regions near a round opening during a bi-axial tension of a thin plate (in Russian), *Trudi Mosk. Aviats. In-ta* no. 69, 11–38, 1956; *Ref. Zh. Mekh.* no. 11, 1957, Rev. 13149.

An approximate solution is furnished for the problem of the elastic-plastic state of a plate with a round opening during two-axes tension. L. A. Galin's method is applied [*Prikl. Mat. Mekh.* **10**, no. 3, 1946], for which purpose the function of stresses in the plastic zone is taken to be approximately biharmonic. Author's assertion notwithstanding, the stresses obtained in the plastic zone can vary at will from the actual. Actually in the plastic zone

$$\left[\sigma_\theta = \sigma_z \quad 2A + B\frac{R^2}{r^2} + 2C\ln\frac{r}{R} + 3C\right]$$

where

$$A = \frac{1}{2}\left(1 - \frac{R}{a} - \frac{R}{2a}\ln\frac{a}{R}\right)$$

$$B = \frac{a}{4R},\ C = \frac{R}{4a}$$

R is the radius of the opening, r the flow radius, a the magnitude characterizing the dimensions of the plastic zone. When $a \to \infty$, $A \to \frac{1}{2}$, $C \to 0$, $B \to \infty$, and therefore, at any delimination of r, $\sigma_\theta \to \infty$. To agree with the precise solution $\sigma_\theta = \sigma_z$.

D. D. Ivlev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4367. Gorb, M. L., Resistance to plastic deformation of high performance steels in conditions of three-dimensional uneven compression at high temperatures (in Russian), Avotrefer. Diss. Kand. Tekhn. Nauk, In-ta Stroit. Mekhan. Akad. Nauk SSSR, Kiev, 1957; *Ref. Zh. Mekh.* no. 10, 1957, Rev. 12270.

4368. Ranzin, Ya. R., and Zheleznyakova, A. R., The initial stage of plastic deformation in polycrystalline metals and the influence of particle size (in Russian), *Fiz. Metallov i Metallovedenie* **3**, 1, 155–161, 1956; *Ref. Zh. Mekh.* no. 11, 1957, Rev. 13529.

Experiments were conducted with pure iron (in %: 0.04C, 0.07Mn, 0.13Si, 0.012P, 0.036S, 0.12Cu) with grain sizes of 0.06 to 1.5 mm. The commencement of the visible appearance of shear was determined on the polished side of the discontinuous sample at a magnification of × 500, and the initial form of the portion of the stress diagram was studied. The magnitudes of deformation resulting in the appearance of shear were determined, and also the length of the plane of flow in relation to the particle size. It was noted that the area of the plane of flow is linked with the intergrain migrations in the initial stage of deformation.

P. O. Pashkov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4369. Ranzin, Ya. R., The initial stage of plastic deformation in polycrystalline metals and the influence of particle size; I. Aluminum (in Russian), *Fiz. Metallov i Metallovedenie* **3**, 1, 146–153, 1956; *Ref. Zh. Mekh.* no. 11, 1957, Rev. 13528.

With the assistance of a method demonstrated in previous works of the author [Trans. of the Conference on the thermal treatment of metals; Mashgiz, 1954], a study was made of the initial stage of the plastic deformation of polycrystalline aluminum of 99.48 to 99.90% purity. The boundaries of shift were investigated; these appeared initially as intergrain migrations of shear deformation inside the grains. It was shown that the boundary between these two mechanisms of deformation depends on the deformation velocity, on the condition of the boundary transit layer and the particle size. When deformation only takes place by intergrain migration the annealing of the riveted metal leads to collective re-

crystallization. The recrystallization zone is studied after transition to shear deformation and when there are violent distortions near the particle boundaries. The relative experimental data are given. P. O. Pashkov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4370. Lippmann, H., Foundations of mathematical plasticity theory based on crystal plasticity (in German), *Ing.-Arch.* **26,** 3, 187–197, 1958.

The stress-strain relations generally used in the mathematical theory of plasticity are phenomenological ones, based on experiments made, e.g., on steel at simple tension. In contrast to this the author starts from a crystal lattice model, assuming that the material under consideration is composed of a great number of small crystal grains. A new type of stress-strain relation is proposed, and it is proved on some examples of uniaxial tension and compression. An interpretation is given for the dependence of the yield limit on the strain rate.

F. Chmelka, Austria

4371. Shchukin, E. D., Goriunov, Iu. V., Pertsov, N. V., and Rozhanskii, V. N., On the nature of jerky plastic deformation in metallic single crystals, *Soviet Phys.-Doklady* **3,** 1, 96–98, Dec. 1958. (Translation of *Dokladl Akad Nauk SSSR (N.S.)* **118,** 2, 277–279, Jan.-Feb. 1958 by Amer. Inst. Phys., New York, N. Y.)

4372. Mott, N. F. (under the leadership of), **A discussion on work-hardening and fatigue in metals,** *Proc. Roy. Soc. Lond. (A)* **242,** 1229, 145–227, Oct. 1957.

Eleven papers on theoretical and experimental aspects. Most of experimental work was done on annealed pure metals or single crystals. Under alternating stress, slip bands are heavier, less numerous than in unidirectional stressing. Bands which persist after repolishing are sources of fatigue cracks, but presence of persistent slip bands does not necessarily mean that fatigue cracks will develop. Other unusual microscopic features associated with repeated stressing, such as intrusions and extrusions on surface, are observed under amplitudes of stressing much less than that necessary to initiate a fatigue crack. Therefore relation to fatigue damage is unclear. Neither changes in hardness, x-ray diffraction pattern, nor rate of release of stored energy were found to correlate with the progress of fatigue. Fatigue failures were observed at 4°K, indicating that diffusion and surface reactions are not essential to the fatigue process. Effect of temperature and speed of testing on mild steel could be explained on the basis of strain-ageing. Studies of fatigue crack propagation showed that nonpropagating cracks occurred only when minimum stress in cycle was less than zero. J. A. Bennett, USA

4373. Tardif, H. P., and Erickson, W., Strain-aging, work-hardening, and inhomogeneous deformation in Armco iron after static and dynamic deformation, *J. Appl. Mech.* **25,** 2, 285–287 (Brief Notes), June 1958.

4374. Ketter, R. L., The influence of residual stress on the strength of structural members, *Welding Res. Counc. Bull. Ser.* no. 44, 11 pp., Nov. 1958.

Concerned primarily with the stability of "as-delivered," rolled, structural steel shapes of the I or WF type, this discussion considers the influence of residual stresses on the load-carrying capacity of compressed members. Both the pure axial load case and that of combined thrust and bending due to end moments, eccentric or lateral loads, etc. have been included.

From author's summary

Rods, Beams and Strings

(See also Revs. 4282, 4322, 4330, 4348, 4349, 4418, 4443, 4479)

4375. Voinea, R. P., and Voinea, D. P., Contribution to the strength calculation of flexible electric conductors (in French), *Acad. Repub. Pop. Romine, Rev. Mecan. Appl.* **3,** 3, 341–356, 1958.

Paper establishes a relation between the static elements of a flexible wire suspended at any two points and the static elements of a simply supported beam. This allows one to determine, in a general form, the equation relating the stresses in the wire which correspond to two states characterized by different loadings and temperatures.

Case of concentrated and distributed load is analyzed. Results are applied to the case of a steel-aluminum conductor. For this purpose authors determine the expansion coefficient and Young's modulus for a fictious homogeneous conductor of the same length as the actual one.

An application for the technical and climatic conditions prevailing in Roumania is included. A. Petre, Roumania

4376. Goldsmith, W., An elongating string under action of transverse force, *J. Appl. Mech.* **24,** 4, 609–616, Dec. 1957.

See AMR **11** (1958), Rev. 782.

4377. Shuleshko, P., A method of obtaining the equation of the deflection curve of beams, *J. Instn. Engrs. Austral.* **30,** 9, 281–283, Sept. 1958.

Author proposes method for obtaining the deflection curve of a beam "without any integration" by assuming the deflection curve to be represented by a power series whose coefficients are determined by the boundary conditions. Method is said to be based on the "method of four parameters" proposed by various Russian scientists. Several examples of application of method are given. Main difference from usual treatment of beams appears to be that initial step of obtaining the power series by integrating the differential equation is omitted. J. W. Clark, USA

4378. Gorgidze, A. Ya., Secondary effects in the problem of deflection of a prismatic beam by a transverse force (in Russian), *Soobshch. Akad. Nauk GruzSSR* **16,** 9, 665–672, 1955; *Ref. Zh. Mekh.* no. 11, 1957, Rev. 13018.

An investigation is made, within the framework of the quadratic theory of elasticity, of the problem of the secondary effects in the deflection by a transverse force of a prismatic beam, made up of various elastic materials.

It is assumed that the materials making up the beam have identical Poisson coefficients but, speaking generally, different moduli of elasticity. Making use of the methods of the nonlinear theory of elasticity [N. V. Zvolinskii, *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* 1938, (8–9)], the problem in question merges in the linear theory with the problem of the deformation of a compound prismatic beam in the presence of the determined spatial and surface forces. Further, the obtained spatial linear problem on the deformation of the compound prismatic beam leads to the case where the spatial forces are not present. However, it is not a difficult matter to construct an effective solution of the obtained spatial linear problem by bringing it to the boundary problems for a plane compound region (transverse section of the beam). A. K. Rukhadze

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4379. Voinov, A. P., Steel-wood beams (in Russian), Nayk. Pratsi Khar'kovsk. In-ta Inzh. Komun. Budivnitsva no. 7, 17–60, 1956; *Ref. Zh. Mekh.* no. 11, 1957, Rev. 13409.

Theoretical and experimental investigations show that the carrying capacity of wooden beams can be increased if the zone in tension is reinforced by glueing a steel strip to it at a temperature of 160–200°, the glue being of the water-resistant type BF-2 or BF-4. As a result, initial stressing occurs, which increases the load-carrying capacity of the beam. Methods of calculation and the results of tests are given. A. V. Dyatlov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Book—4380. Afendul'ev, A. A., and Skipskii, P. S., Methods for calculations for beams on an elastic foundation under the action of a one-sided bond (in Russian), Gor'kovsk. Inzh.-Stroit. In-ta, Gor'kii, 1957, 36 pp. + illus.; *Ref. Zh. Mekh.* no. 10, 1957, Rev. 12086.

4381. Silberstein, J. P. O., Stresses in a beam rotating in a conical path helicopter blade subject to uniform lift, *Aero. Res. Consult. Comm. Aero. Res. Lab., Melbourne, Austral.* Structures and Materials Note 242, 12 pp., Apr. 1958.

In helicopter blade analysis, it is usual to use approximate energy methods to obtain blade stresses under various loading conditions. The results obtained may vary widely in accuracy of solution.

Authors have obtained an exact solution for the deflection and bending moments of a rotating beam. Solutions are in the form of power series which, though everywhere convergent, do so somewhat slowly for large values of the independent variable. Two power series solutions are employed to solve the cantilever problem in which boundary conditions at each end have to be fitted. One uses expansion in terms of distance from the axis of rotation; the other in terms of distance from the blade tip.

A numerical example illustrates the technique. The rate of convergence (number of terms required) is discussed in an appendix.

From author's summary by E. L. Foster, USA

4382. Young, Y. F., and Scordelis, A. C., An analytical and experimental study of helicoidal girders, *Proc. Amer. Soc. Civ. Engrs.* **84,** ST 5 (*J. Struct. Div.*), Part 1, Pap. 1756, 29 pp., Sept. 1958.

A useful analysis of helicoidal girders with different width-depth ratios is presented. The structures being considered as prismatic, analytical results are obtained by the usual method of computing the virtual displacements corresponding to the redundant forces and moments and equating these. Involved expressions of such displacements are presented in Appendix. Experimental influence lines of the end reactions, obtained on a plexiglass model by the Beggs method, are compared with the analytical ones, good agreement being obtained.

Results make possible a perfect understanding of the behavior of this type of structure, up to width-depth ratios of 16. It is to be noted that to the increase of the width-depth ratio corresponds an increase of the twisting and bending moment with vertical axis at the supports and a simultaneous decrease of the moment with horizontal axis.

It would have been of interest, for design purposes and to allow comparison with results observed in real structures, to present the influence line of the vertical displacement for the point at middle height, which could have been easily determined on the model.

F. Borges, Portugal

4383. Walther, R., Stresses in reinforcing rods in reinforced concrete beams (in German), *Schweiz. Bauztg.* **74,** 2, 13–17, Jan. 1956.

4384. Solomon, L., Bending of the symmetric cantilever beam without torsion (in Roumanian), *Acad. Repub. Pop. Romine Comun.* **8,** 10, 1011–1021, 1958.

Author proves that a force acting in the end cross section along a main axis which at the same time is a symmetry axis produces pure bending without torsion.

Reviewer believes that the demonstration may be simplified by using Saint-Venant's principle and the general theorems of the theory of elasticity in the case of a cantilever under a load whose resultant force and moment are vanishing.

M. Misicu, Roumania

4385. Vocke, W., Determination of exact torsion spring values (in German), *Maschinenbau-Technik* **6,** 10, 545–549, Oct. 1957.

Author derives more accurate formulas for the torsional rigidity of shafts with circumferential notches. The notch-effect is given in form of additional lengths of the shafts.

H. Neuber, Germany

4386. Yakovleva, V. I., Torsion of a tapered prismatic rod of elliptical section (in Russian), *Trudi Gruz. Politekhn. In-ta* no. 1(42), 107–112, 1956; *Ref. Zh. Mekh.* no. 3, 1958, Rev. 3154.

Author investigates the torsion of a tapered prismatic rod, the transverse section of which is bounded exteriorly and interiorly by confocal ellipses. By reflecting the transverse section of the rod on a circular ring, it is possible, as is known, to bring in the problem on torsion to the determination of the functions of torsion, holomorphic inside the ring and satisfying the determined boundary conditions. Making use of the presentation in the form of stepped series in the case being investigated, author determines the torsion function and the stress components during torsion; a curve is also drawn to show the stresses on the external and internal contours of the section. A. K. Rukhadze

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4387. Kostandyan, B. A., Torsion of a tapered stepped shaft (in Russian), *Izv. Akad. Nauk ArmSSR, Fiz. -Matem., Estestv. i Tekhn. Nauk* **9,** 3, 17–32, 1956; *Ref. Zh. Mekh.* no. 3, 1958, Rev. 3153.

An investigation is made of the torsion of a tapered shaft with a stepped axis section, when a symmetrical load is applied to its ends, the load being dependent only on the radius. With the aid of the Fourier method the solution of the given problem is looked for in the form of series of Bessel functions, the coefficients of which are determined from an infinite, fully regular system of linear equations. Formulas are also brought in, in the form of series, for the determination of the stresses in points of the axis section. As an example, the problem is analyzed of the torsion of a tapered stepped shaft when the load, applied to the ends of the shaft, varies linearly along the radius of the section.

A. K. Rukhadze

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Plates, Shells and Membranes

(See also Revs. 4320, 4321, 4325, 4329, 4337, 4359, 4366, 4413, 4433, 4459, 4732, 4733)

4388. Degenkolb, H. J., Design of pitched and curved timber diaphragms, *Proc. Amer. Soc. Civ. Engrs.* **85,** ST 1 (*J. Struct. Div.*), Pap. 1911, 65–75, Jan. 1959.

The forces are shown which exist (a) in plane diaphragms with plywood sheathing, diagonal lumber sheathing with one-half of it at a 45° angle and the other one-half at a 135° angle, double diagonal sheathing at 45° and 135° angles, (b) in pitched diaphragms with sheathing of one diaphragm plane in continuation or at 90° angle to sheathing of second diaphragm plane, (c) in curved diaphragms on a bowstring truss, (d) in curved diaphragms with

diagonal sheathing along top and bottom of arched girder, (e) in nonplanar, broken diaphragms of roof with two different slopes. The stresses resulting from some of these forces are computed for given examples. E. G. Stern, USA

4389. Vodicka, V., Elementary solution of some plate problems (in English), *ZAMP* **9a**, 2, 206–210 (Brief Reports), July 1958.

Author presents a solution of the usual plate bending equation for the elliptic boundary with fixed edge condition, but with the loading function generalized in the form of a polynomial of any degree. A solution is presented in detail for the second-order polynomial loading function. Author states that his methods can be usefully applied in solving other boundary-value problems, not only of the biharmonic but also of the polyharmonic and harmonic equations. B. G. Johnston, USA

4390. Bassali, W. A., Transverse bending of infinite and semi-infinite thin elastic plates, Part II, *Bull. Calcutta Math. Soc.* **49**, 3, 119–127, Sept. 1957.

Author treats the problem of infinite and semi-infinite elastic plate which is linearly loaded over a circular region. It is assumed that the plate is elastically restrained on the boundary of the loaded region and that the deflection along it vanishes.

Solution for small-deflection theory is worked out by complex variable methods analogous to those used by Muskhelishvili and his school for two-dimensional elastic problems. Solution for the plate loaded by a concentrated couple is obtained as a limiting case.

Last result could perhaps be of use in analyzing the restraining action of a column support on a monolithically joined plate.

Z. Hashin, Israel

4391. Iwinski, T., and Nowinski, J., The problem of large deflections of orthotropic plates (I) (in English), *Arch. Mech. Stos.* **9**, 5, 593–603, 1957.

Authors generalize a method for analysis of bending of isotropic plates to moderately large deflections. The method was proposed by H. M. Burger [*J. Appl. Mech.* **22**, 465–472, Dec. 1955]. It involves neglecting the so-called second strain invariant. In the present paper, Eq. (1.9) which represents a generalization to the orthotropic case of the nonlinear von Kármán plate equations is attributed to G. G. Rostovcev. Authors remark that solutions for orthotropic plates with large deflections are unknown to them. Reviewer can point out that interesting solutions do exist and for the more general boundary conditions of elastic rotational constraint. These are given by W. G. Soper [NOnr Rept., contract 248(12), Johns Hopkins University; Johns Hopkins Dissertation 1956, and *J. Appl. Mech.* **25**, Dec. 444–448, 1958]. It may be interesting to compare authors' results with these which check very well with experimental data.

W. H. Hoppmann, II, USA

4392. Frasier, J. T., and Rongved, L., Force in the plane of two joined semi-infinite plates, *J. Appl. Mech.* **24**, 4, 582–584, Dec. 1957.

See AMR **11** (1958), Rev. 2515.

4393. Kaul, R. K., and Tewari, S. G., Bounds of eigenvalues of a clamped plate in tension, *J. Appl. Mech.* **25**, 1, 52–56, Mar. 1958.

See AMR **11** (1958), Rev. 1988.

Book—4394. Korotkin, Ya. I., Lokshin, A. Z., and Sivers, N. L., Deflection and strength of plates and round cylindrical shells; Constructional mechanics of the ship (A text book for shipbuilding courses in higher teaching institutions and faculties) (in Russian), Sudpromgiz, 1955, 308 pp. + illus. 6r 95k; *Ref. Zh. Mekh.* no. 3, 1958, Rev. 3176.

In the first chapter a detailed account is given of the theory of plates, deflecting along the cylindrical surface; equations are derived for the determination of the unknown longitudinal force and a concept is put forward regarding the reduction coefficient of the plates participating in the general flexure of the ship. The second chapter is devoted, in the main, to the deflection of stiff rectangular plates. Solutions are given in detail of the problems on the deflection of plates, made with the aid of common trigonometrical series. Examples are given of the solutions of problems of the bending of plates, carried out by means of the energy method and the Kantorovich method. An exposition is given of the theory for the calculations for a compound plate, of some solutions of problems regarding the complex deflection of plates, and some ideas are advanced regarding the methods to be used for solving the problem of the deflection of plates with extensive bending. In particular, a complete deduction is furnished for the differential equations for the deflection of plates with extensive bending.

In the third chapter a detailed analysis is given of the solution of a series of problems on the strength of rectangular plates used in shipbuilding calculations; examples are furnished of solutions by the method of integration of a differential equation, by the energy method and by the Bubnov-Galerkin method. P. F. Papkovich's theorem is substantiated regarding the stability of the elastic system under the action of several special loads. The question is gone into of the behaviour of a compressed plate, after the loss of stability (P. A. Sokolov's problem). In the fourth chapter the solution is published of the problem on the deflection of a cylindrical shell subjected to a peripheral evenly distributed pressure; the solution of the problem is stated in a closed form. In the fifth chapter an examination is made of the stability of a ring, a round cylindrical shell, and distorted plates, when subjected to even pressure. The problem on the stability of a ring is solved by the method of integration of the equation for deflection; the solutions, however, of the stability of the shell and the plate are accomplished by means of the energy method, but only in its linear arrangement. A. A. Kurdyumov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4395. von Willich, G. P. R., The elastic stability of thin spherical shells, *Proc. Amer. Soc. Civ. Engrs.* **85**, EM I (*J. Engng. Mech. Div.*), Part I, Pap. 1897, 51–65, Jan. 1959.

A nonlinear theory of shallow shells under uniform pressure is used. Deflected shape is assumed in form of polynomial with two undetermined coefficients, and critical pressure is calculated by applying principle of stationary potential energy. Results agree reasonably well with experimental and more exact theoretical results.

Reviewer believes basic idea illustrated in paper is noteworthy. More accurate results applicable to wider range of parameters could be obtained by assuming more general form of deflected shape. This would not be practical unless more powerful calculating device such as electronic computer is employed. Reader's attention should be directed to work of Mushtari [AMR **4** (1951), Rev. 2859] using similar method, also to more recent work of Reiss [*J. Appl. Mech.* **25**, 4, 556–560, Dec. 1958] using different method of approximation and obtaining more accurate results.

B. S. Wilson, USA

4396. Reissner, E., Symmetric bending of shallow shells of revolution, *J. Math. Mech.* **7**, 2, 121–140, Mar. 1958.

Starting with the basic equations for the axisymmetric deformation of shells of revolution, together with the assumptions for shallowness, author derives two simultaneous nonlinear second-order differential equations for a class of problems of elastic shells indicated by the title. The nonlinear effects occur in the (membrane) strain-displacement relations, and the linear stress-strain law (for orthotropic materials) employed admits variation of

the elastic constants with coordinates (while the thermal effect is also included in the stress-strain relations, it is omitted in the remainder of the paper). For isotropic and homogeneous shells, and in the absence of thermal effects, the derived equations become special cases of those of the general shallow shells given by Marguerre [Proc. 5th Intern. Congr. Appl. Mech., 1938; pp. 93-101] and also of the earlier work of the author [Proc. Symp. Appl. Math., **3**, 27-52, 1950; AMR **4** (1951), Rev. 1985].

The derived general equations are applied to two problems. The first is concerned with the edge effects in a homogeneous and isotropic shallow spherical shell subjected to a uniform axial load according to the nonlinear theory. The second problem deals with the orthotropic shallow spherical shell subjected to a uniform axial load within the scope of the linear theory. It is found that for this latter problem the character of the solution is fundamentally altered in that while the linear membrane theory furnishes an appropriate solution for the interior of the isotropic shell, the corresponding membrane solution for the orthotropic shell is inadmissible. The solutions to both problems are accompanied by numerical calculations. P. M. Naghdi, USA

4397. Olesiak, Z., Application of trigonometric series to the computation of closed cylindrical shells (in Polish), *Rozprawy Inz.* **6**, 2, 267-280, 1958.

The deflection of a circular tube subjected to an axially symmetrical load and that of a beam resting of an elastic foundation are described, as is known, by the same differential equation of the fourth order. Making use of this analogy, author uses the known solutions for beams to solve problems of closed cylindrical shells supported on one or more circles.

From author's summary by M. Sokolowski, Poland

4398. Vogel, T., On the inverse spectral problem in the theory of elastic shells (in French), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **6**, 235-241.

Paper deals with the transmission of a vibration, caused by an exciter, in an elastic shell; functional analysis is applied for an approximative computation. Author shows, for example, that a spherical calotte excited by a sound impulse possesses an "exclusion-zone" in a certain interval, marked by absence of natural frequency. Comparison of spherical calotte with sloped (flattened) calotte indicates an extension of this zone in the second case. Tests executed with aluminum-sheet shells confirm results obtained by theoretical computation. H. Beer, Austria

4399. Golubovic, G. B., Theoretical and experimental contributions to the study of the basic hypotheses of the theory of shells of revolution (in French), 9th Congrès Intern. Mecan. Appl., Univ. Bruxelles, 1957; **6**, 263-271.

A model of a hyperbolic revolution-shell, formed by an aluminum sheet, is tested by applying different types of load, as e.g. wind pressure, external forces acting on the edges and considering also effects of variation of temperature. Results of these investigations confirm basic suppositions of classic theory of revolution shells stated by Geckeler and applied by the author to the special case of the hyperbolic-shaped shell in a former paper. Special attention is given to the influence of time with the variation of temperature, taking into account the great inertia of the base.

H. Beer, Austria

4400. Cooper, R. M., Cylindrical shells under line load, *J. Appl. Mech.* **24**, 4, 553-558, Dec. 1957.

See AMR **11** (1958), Rev. 2068.

4401. Khazaliya, G. I., Problem of establishing by means of an experimental-theoretical way schemes for studying fracture of spherical hollow shells (in Russian), *Soobshch. Akad. Nauk GruzSSR* **18**, 1, 75-82, 1957; *Ref. Zh. Mekh.* no. 11, 1957, Rev. 13178.

An experimental investigation was carried out to ascertain the true character of the distribution of stresses, to determine the bending, to note the appearance of the actual carrying capacity of the shells and to find out the reasons for their fracture. The forms taken in the process of fracture were also determined experimentally. On the basis of the experiments, carried out with gypsum (plaster of paris) shells, the applicability was established of calculation plans of the fractures, previously adopted by the author, and also the suitability of an approximate elastic-plastic computation of a plate on an elastic foundation for the calculations for shells. L. A. Movsisyan

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4402. Krivosheev, N. I., Influence of initial irregularities in the form of the mean surface on the strength of cylindrical shells when subjected to torsion (in Russian), *Izv. Kazansk. Fil. Akad. Nauk SSSR, Ser. Fiz.-Matem. i Tekhn. Nauk* no. 10, 69-80, 1956; *Ref. Zh. Mekh.* no. 7, 1957, Rev. 8171.

The behavior is examined of a round cylindrical shell under the action of a torsional couple applied to the faces; the deflections are assumed to be comparable with the thickness of the shell. Having in mind shells of "mean length," author makes use of the usual dependencies relating to hollow shells. The mean surface is brought into the oblique-angled dekastron system of coordinates. Coordinate y_1 is calculated along the arc of the transverse section, coordinate x_1 along the line, making with the arc an angle $\frac{1}{2}\pi + \varphi$. The equation is recorded for the nature of deformation and the expression for a system's energy in such coordinates. Examining the stability of the shell "for a minimum," author adopts an expression for deflection in the case of a jointed support of the faces in the form of

$$w = ft \sin mx_1 \sin \bar{n}y_1 \qquad [1]$$

and in the case of fastened faces in the form of

$$w = ft \sin^2 mx_1 \sin \bar{n}y_1 \qquad [2]$$

Here $m = \bar{n}/l_1$, $\bar{n} = nR$; l = the length of the shell, t is the thickness, R the radius, n the number of waves around the vicinity. The static boundary conditions along the faces are satisfied "for the mean." The results of the calculations of critical stresses are compared with the data of Kh.M.Mushtar's works [*Izv. Fiz.-Mat. ob-va Kazansk. Gos. un-ta*, 1938], Donnell's [L. H. Donnell, *NACA Rep.* 479, 1933], Batdorf's and Stein's [S. B. Batdorf, M. Stein, [*NACA TN* 1345, 1947]. When investigating large deflections author assumes that the shell has an initial deflection according to the equation

$$w_0 = f_0 t \left(\sin mx_1 \sin \bar{n}y_1 + f_1 \sin^2 mx_1 \sin^2 \frac{ny_1}{2} \right) \qquad [3]$$

The expression for the auxiliary deflection is approximated in the form of

$$w = f_1 t \left(\sin mx_1 \sin \bar{n}y_1 + f \sin^2 mx_1 \sin^2 \frac{\bar{n}y_1}{2} \right) \qquad [4]$$

It is assumed that under the load action the initial irregularities redevelop, retaining their form. It is supposed that along the faces the shell is fastened by means of frame works, the deformation of which along the arc is equal to zero. Expressions [3] and [4] are substituted in the equations of joint deformations; the stress function is found. After this, Ritz's method is applied; the full energy varies along two parameters, linked with f_1 and f. Further, a determination is made, as the outcome of the condition of minimum load, of two other parameters, characterizing the angle of declination of the bulge φ and the number of waves n. A relationship curve is found between the load and the line of auxiliary deflection. By the term "critical" is understood a load in con-

sequence of which a rapid increase in deflections take place. The value found is compared with the experimental data of Lundquist and Donnell. Judging by the curve of load - deflection in the absence of initial irregularities the load value drops monotonously from the upper critical value to the extent of the deflection increase, so that it is impossible to find the lower critical point within the limits of the deflection values being investigated. Another such case is also examined, when the initial deflection is determined through the expression

$$w_0 = f_0 t \sin^2 mx_1 \sin^2 \frac{\overline{n}y_1}{2} \qquad [5]$$

Author comes to the conclusion that the upper critical load A for a shell having initial irregularities may be approximately expressed through the critical load A_1, found in accordance with the linear theory with the aid of the following relation:

$$A = A_1 (1 - 0.6 w_{0_{max}} / t) \qquad [6]$$

With the condition that $w_{0_{max}} \leqslant 0.25t$, $w_{0_{max}}$ is the line of the initial deflection. Another variant of the solution for a similar problem is given in Lu's article [Proc. 2nd U. S. Nat. Congr. Appl. Mech. 1954]. A. S. Vol'mir

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4403. Lunchick, M. E., and Short, R. D., Jr., Behavior of cylinders with initial shell deflection, *J. Appl. Mech.* **24,** 4, 559-564, Dec. 1957.
See AMR **11** (1958), Rev. 1176.

4404. Mizoguchi, K., On shear lag in thin-walled cantilever pipes, *Bull. JSME* **1,** 4, 361-366, Nov. 1958.

By solving a differential equation given in a previous paper by the same author based on strain energy, with the suitable boundary conditions, author derives deflections and stress components for a cantilevered cylindrical shell loaded with a concentrated load P at the free end. Although deflections and axial normal stresses derived in this paper almost coincide with those given by the modified and simple beam theory, respectively, the results of this paper are useful as to the shearing stresses at or near the fixed end, and the circumferential normal stresses which cannot be predicted by simpler theories. One important conclusion drawn by the author is that at the fixed end the load P is balanced by circumferential shearing force for short cylinders and by transverse shearing force for long cylinders, while at a little distance from the fixed end the load P is always balanced by circumferential shearing force. J. D. Marketos, USA

4405. Soule, J. W., Tensor flexibility analysis of closed-loop piping systems, *J. Appl. Mech.* **25,** 1, 11-16, Mar. 1958.
See AMR **11** (1958), Rev. 2511.

Buckling

(See also Revs. 4349, 4437)

4406. Kloppel, K., and Schardt, R., Contribution to the practical solution of columns under load with simple symmetric open thin wall cross-sections, Parts I, II (in German), *Stahlbau* **27,** 2, 35-42, Feb. 1958; **27,** 10, 262-270, Oct. 1958.

Owing to the discrepancy between the center of gravity and the center of elasticity of opened thin-wall cross section of a buckled stout the coupling of transverse and rotation displacements takes place. Mathematically this problem is govemed by three simultaneous differential equations containing certain linear coupling terms. Authors investigate the lowest proper value corresponding to the first critical buckling load.

Considering the linearity of basic differential equations with constant coefficients and the fact that these equations contain the second and the fourth derivatives, only the exact solution may be written in trigonometric functions. The critical load follows from the condition of nontrivial solution. The comparative slenderness was defined as a slenderness of a column the critical load of which (without coupling) coincides with that when coupling effect is taken into account.

Many practical diagrams based on formulas DIN 4114 Ri 7.53, enabling an easy determination of comparative slenderness for various cross-section shapes and end conditions, were obtained. Paper contains many practical notes and is considered a very useful guide in numerical evaluation of comparative slenderness. The results of experiments are presented.
K. Julis, Czechoslovakia

4407. Hunyadi, F., Lateral buckling of steel girders of constant cross-section (in Hungarian), *Mélyépitéstudományi Szemle* **8,** 8/9, 394-401, Aug.-Sept. 1958.

Author derives formulas for the stress analysis of steel girders, taking into account the risk of lateral buckling. The treatment concerns both monosymmetrical and bisymmetrical cross sections. The solution of the stability problem is based on the assumption of an initial curved shape. This assumption conforms to the Hungarian Standard Specifications referring to the stress analysis of compressed straight bars. A numerical example shows the details of computing. J. Barta, Hungary

4408. Hunyadi, F., Lateral buckling of steel girders with constant and variable cross sections (in Hungarian), *Epitoipari es Kozl. Musz. Egyetem Tud. Közlemények* **4,** 1, 11-41, 1958.

The expositions of the paper of the preceding review are completed here. Then the results are extended for the case of girders of variable cross section. The use of formulas deduced by author is illustrated by numerical examples. J. Barta, Hungary

4409. Tarasenko, I. I., Calculations for stiff rods subjected to eccentric compression and eccentric tension (in Russian), 15th Scientific Conference of the Leningrad Engineering Construction Institute, Leningrad, 1957, 382-386; *Ref. Zh. Mekh.* no. 3, 1958, Rev. 3248.

Reasons are given for the belief that it would be possible to significantly increase the initial value of the standard for the permissible stresses of the eccentric compression and eccentric tension of rods made of plastic deforming materials, when the calculations are carried out not by the boundary state but by the condition of the elastic phase of the deformation. Formulas are proposed for the coefficients, permitting, from the permissible stresses for simple tension and simple compression, going-over to the conditions of the permissible stresses during eccentric tension and eccentric compression. The above coefficients were determined as the outcome of the actual curvilinear diagrams of deformation of the material and the elastic-plastic zones and, approximately, by means of the rectification of the curve from the limit of proportionality to the limit of yield. N. I. Bezukhov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4410. Ades, C. S., Bending strength of tubing in the plastic range, *J. Aero. Sci.* **24,** 8, 605-610, Aug. 1957.

Author uses the principle of least work to determine analytically the total work of a bent and deformed tube under elastic and plastic state of stress. The shape of tube cross section is found as a function of longitudinal curvature. The bending moment carried by the tube is then found from the shape of the tube cross section; hence curves of bending modulus of rupture are constructed for in-

itially round tubing. A more accurate theory for elastic and plastic buckling and ovalization for D/t greater than 50. In view of above a gratifying agreement with the available test data is evidenced.

Z. W. Dybczak, Canada

4411. Korolev, A. A., Investigation of the stability of a plate of variable thickness under the influence of tangential stresses (in Russian), *Izv. Vses. N.-i. In-ta Gidrotekhn.* **57**, 112–128, 1957; *Ref. Zh. Mekh.* no. 11, 1957, Rev. 13080.

The problem is examined of the stability of a plate consisting of three portions according to width: the middle portion of constant width, while the thickness of the outside portions changes in accordance with the principles of a hyperbolic cosine. The problem is solved by the energy method.

A. A. Kurdyumov

Courtesy Referativnyi Zhurnal, USSR Translation, courtesy Ministry of Supply, England

4412. Pavlov, A. P., Local warping of wood (in Russian), *Sb. Leningr. In-ta Inzh. Zh.-d. Transp.* no. 150, 45–59, 1956; *Ref. Zh. Mekh.* no. 11, 1957, Rev. 13601.

Two forms of warping of wood are examined across the fiber: over the whole surface and on part of the length. For the warping stress over the whole surface a formula is obtained which agrees with the experimental data. Local warping is considered as a plane problem. With increase of the warped plane the distribution of stresses approaches the case of warping over the whole surface. Under the action of concentrated forces the stresses of warping over the whole surface and of local warping differentiate by $K = \sqrt{E_2/E_1}$ times, where E_1 and E_2 are moduli. The stresses are examined when subjected to the action of a force with an arbitrary angle of inclination to the boundary of the plate, and a three-dimensional diagram is built to show the stress changes due to the relation between the angle of inclination of the force to the fibers.

K. V. Panferov

Courtesy Referativnyi Zhurnal, USSR Translation, courtesy Ministry of Supply, England

4413. Grigolyuk, E. I., Plastic buckling of shells of revolution (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 2, 130–132, Feb. 1958.

Based on equations of local instability of shells [*Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 10, 1957, same author], buckling formulas for surfaces of revolution beyond elastic limit are developed. Both Prandtl-Reuss and Hencky materials are considered. Unloading of any point on the shell is excluded from consideration.

E. P. Popov, USA

Vibrations of Solids

(See also Revs. 4291, 4351, 4445, 4446, 4463, 4515, 4524, 4732, 4733, 4811)

4414. Payne, L. E., and Weinberger, H. F., Lower bounds for vibration frequencies of elastically supported membranes and plates, *J. Soc. Indust. Appl. Math.* **5**, 4, 171–182, Dec. 1957.

Investigation uses minimum principle (Rayleigh's formula extended on elastic supports) applied to the actual problem and appropriate one-dimensional auxiliary problems, e.g. membranes and strings respectively, produced by intersection of the given problem with coordinate lines. Mentioned principle always gives upper bounds for eigenvalues, and these eigenvalues only if corresponding eigenfunction is used. However, auxiliary problems must be solved explicitly.

Minimum principles used for auxiliary problems introduce the two restraint constants, while that of the actual problems only contains the one given constant. Comparison of these principles gives such condition between these constants that the sum of eigenvalues of the auxiliary problems surely is lower than the eigenvalue of the given problem. Mentioned condition allows to vary constants to get highest lower bound.

Method is applied on membranes whose boundaries are supported elastically. Here also an annular membrane is used as an auxiliary problem. If supporting restraint constant becomes very small, also second eigenvalue is regarded. It is possible to deal with three-dimensional problems concerning acoustic resonators with elastic walls. Elastically clamped plates need four constants to be found analogically. Finally eigenvalues of plates are expressed by those of membranes.

W. Mudrak, Austria

4415. Burgreen, D., Effect of end-fixity on the vibration of rods, *Proc. Amer. Soc. Civ. Engrs.* **84**, EM 4 (*J. Engng. Mech. Div.*), Pap. 1791, 10 pp., Oct. 1958.

Paper discusses the transverse free vibrations of a uniform bar with linear elastic end constraints. A solution is obtained which contains end fixity as a parameter, and curves of frequency versus end fixity are given. The relation of strain to end fixity is also studied and presented as a graph. It appears to the reviewer that the results may be most useful in determining the load-carrying capacity of structural members by using observed natural frequencies to determine actual end conditions.

C. T. West, USA

4416. Hearmon, R. F. S., The influence of shear and rotatory inertia on the free flexural vibration of wooden beams, *Brit. J. Appl. Phys.* **9**, 8, 381–388, Oct. 1958.

Paper contains the results of a large number of measurements of frequencies of vibration of free-free beams of rectangular cross section made of a variety of woods. The frequencies are, for the most part, outside the range of applicability of the Bernoulli-Euler equation but within the range of applicability of the Timoshenko equations. The latter are used as a basis for computing the elastic properties of the woods from the measured frequencies and dimensions.

R. D. Mindlin, USA

4417. Chegolin, P. M., Investigation of the frequency properties of beams and frames by the method of electric modelling (in Russian), Electric modelling of beams and frames, Taganrog, 1956, 72–98; *Ref. Zh. Mekh.* no. 11, 1957, Rev. 13136.

4418. Kats, M. M., Natural vibrations of a beam, carrying equal masses (in Russian), Investigations regarding the theory of constructions no. 7; Moscow, Gosstroiizdat, 1957, 159–165; *Ref. Zh. Mekh.* no. 11, 1957, Rev. 13127.

4419. Pluzhnikov, G. T., Vibrations of beams loaded with concentrated loads (in Russian), *Naucb. Zap. Kievsk. Finans.-Ekonom. In-ta* no. 4, 194–202, 1955; *Ref. Zh. Mekh.* no. 3, 1958, Rev. 3221.

Using the energy method a determination is effected of the spectrum of the frequencies of the natural vibrations of a doubly supported beam, loaded with equal concentrated loads, distributed at equal distances along its length. The equation of the vibrating axis of the beam is expressed through beam functions. The frequency of the beam loaded with a distributed load is obtained by the boundary conversion. Comparison of the calculations obtained with the results of the exact solution shows up only a small error in the approximate solution. An investigation is made by the energy method of the constrained vibrations of a beam with supported ends, loaded with several pulsating concentrated forces. Expressions are obtained for the equation of the elastic line of the stationary part of the constrained vibrations.

V. M. Makushin

Courtesy Referativnyi Zhurnal, USSR Translation, courtesy Ministry of Supply, England

4420. Sharafutdinov, V. I., The influence of gravity on the frequencies of natural vibrations of a vertical girder beam (in Russian), *Izv. Akad. Nauk UzbSSR, Ser. Tekhn. Nauk* no. 1, 85-90, 1957; *Ref. Zh. Mekh.* no. 3, 1958, Rev. 3220.

The influence is investigated of the deflection effect of the forces of gravity of a vertical girder beam on the frequency of its free deflection vibrations. The solution of the equation of the dynamic elastic line is sought in the form of a stepped series. For the determination of the first four coefficients use is made of the boundary conditions. For all the subsequent coefficients a recurrent correlation is obtained. The results of the solution are presented graphically in the form of the dependence of the frequency coefficient on the relation of the actual weight of the beam to its critical value. V. M. Makushin

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4421. Burchak, G. P., Three-dimensional vibrations of beam-spanned structures under the action of a movable load (in Russian), *Trudi Mosk. In-ta Inzh. Zh.-d. Transp.* no. 92/11, 74-104, 1957; *Ref. Zh. Mekh.* no. 11, 1957, Rev. 13375.

An investigation is carried out of the natural and constrained vibrations of the span structure of a bridge, consisting of two beams built up into a compound system with longitudinal and transverse bracing. The span structure is investigated as a thin-walled three-dimensional system with a contour capable of deformation. The frequencies of the natural lateral vibrations of the unloaded span structure are determined, and also the torsional vibrations, co-stressed with the distortion of the contour of the section. As a development of the work of the abstractor [*Trudi Mosk. In-ta Inzh. Zh.-d. Transp.* no. 74, 1950; no. 76, 1952] an examination is made of the critical condition of the loaded span structure taking into account the mass of the movable load, which is assumed to be evenly distributed. The question of the constrained deflection-torsion vibrations is discussed.

V. V. Bolotin

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4422. Verontsov, G. V., Determination of the first frequencies of free vibrations of beams carrying concentrated masses, using the method of successive approximations (in Russian), *Trudi Novocherkassk. Politekhn. In-ta* no. 33/47, 133-147, 1956; *Ref. Zh. Mekh.* no. 11, 1957, Rev. 13126.

The free oscillations of beams are investigated, the beams carrying concentrated masses, taking into account the masses of the actual beams. The systems of equations through which, by means of a determinant, the frequency of the free vibrations is found are transposed into an equation for the finding of the critical loading of compressed rods having interstitial rigid or elastic supports, and also for beams lying on an elastic foundation. A system of successive approximations is put forward for finding the frequencies of free vibrations. A. I. Oseled'ko

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4423. Lazaryan, V. A., Investigation of forces appearing during transient regimes of motion in rods with different elastic imperfections (in Russian), *Trudi Dnepropetr. In-ta Inzh. Zh.-d. Transp.* no. 25, 5-50, 1956; *Ref. Zh. Mekh.* no. 11, 1957, Rev. 13179.

Results are given of the stresses in a rod with longitudinal vibrations, when the material of the rod possesses internal friction. The elastic imperfection is scrutinized by the author in two of the simplest cases: in the first case, when the material possesses viscous resistance and the relation between the stress σ and the deformation ε is taken in the form of $\sigma = E\varepsilon + E\mu\,(d\varepsilon/dt)$; and in the second case, when the material shows a clearly defined hysteresis loop. Author examines both the cases in detail and deduces that the stresses for the various moments of time and sections in both cases show no significant differences. But this is understandable as long as the rod material is not assigned too great a proportion of the property of relaxation; for when the author was examining a rod with hysteresis he had in fact the use of the whole process in the first case but only applied the principle of superposition. There are many tables and curves given in the paper, from which the forces, appearing in the rod for a series of sections and different moments of time, can be determined. A. P. Bronskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4424. Gulyaeva, N. I., Integral equation for the vibrations of three-dimensional curvilinear rods (in Russian), *Trudi Leningrad In-ta Inzh. Vodn. Transp.* no. 24, 93-106, 1957; *Ref. Zh. Mekh.* no. 3, 1958, Rev. 3211.

The question is solved in regard to the derivation of a system of integral equations for the vibration of rods of double curvature. With this object in view four tensors of influence are evolved: two tensors for the transformation and two for the pivoting (due to the action of the forces and moments). For elastic material and with the aid of the Kirchoff-Klebsch equations, author brings together 36 components of the tensors of influence and 6 independent components. An example is given for a spring, where the whole of the 36 components is computed. Among the acting forces the force of inertia is included; on the basis of the principle of superposition integrodifferential equations were obtained for three transformations and three pivotal movements. If the assumption is made that the vibrations are sinusoidal, then, after making the appropriate substitution, a system of integral equations is obtained. These integral equations are at first recorded in a vector-tensor form, but later, with the aid of the uniting nucleus, in the form of a single equation. Simplifications are referred to in the case where the moments of inertia forces of rotation can be disregarded. Using the same method, a separate investigation is made of the case of constrained vibrations in the presence of distributed forces. I. S. Arzhanykh

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4425. Mazet, R., Application of a global overall transformation for the study of thermoelastic vibration of structures (in French), *C. R. Acad. Sci. Paris* **245**, 13, 1043-1045, Sept. 1957.

Author considers small-amplitude vibrations of an elastic thermomechanical structure, including external heat transfer as well as internal heat conduction. He shows that expressing the problem in terms of the adiabatic natural vibration modes yields a form of the equations that is simple to interpret.

J. M. Hedgepeth, USA

4426. Polz, K., Frameworks with supported joints and under harmonic dynamic loading (in German), *Bautechnik* **34**, 8, 290-297, Aug. 1957.

Paper aims to use method of Cross on dynamic-loaded frameworks. Influence of normal forces on the act of vibrating is neglected. Well-known solution of deflection curve of a vibrating beam consists of a particular member on the one hand as a result of an active excitation of this span, on the other hand of homogenous members which satisfy boundary conditions. Particular solution analogous to moment distribution method belongs to members built in at one or both ends, while supplemental solutions take into account the rotation of joints. Thus each member possesses dynamic stiffnesses and carry-over-factors depending on excitation frequency. By means of series development of transcendental expressions, useful approximative formulas are given for these characteristic values (stiffnesses and carry-over-factors).

However, performing this concept numerically, no habitual algebraic moment distribution with stepwise approximation is shown, but a system of linear equations, for the same number of moments as there are joints, is solved. Variation of frequency indicates critical values (i.e. natural frequencies) by considerably increasing of moments.

Unfortunately formulas and diagrams show some misprints and absurdities. W. Mudrak, Austria

4427. Raskovic, D., The properties of eigenfunctions for transverse vibration of homogeneous beams, taking into consideration the influence of shearing and rotational inertia (in Polish), *Rozprawy Inz.* **6**, 2, 205–217, 1958.

A method is described for obtaining the eigenfunctions and the frequency equations for straight beams of constant cross section undergoing free vibration; tables are given for various boundary conditions comprising 25 cases.

The influence of the shear forces and the rotational inertia of the cross section is taken into consideration in each case.

M. Piatek, Poland

4428. Schilhansl, M. J., Bending frequency of a rotating cantilever beam, *J. Appl. Mech.* **25**, 1, 28–30, Mar. 1958.

See AMR **11** (1958), Rev. 1502.

4429. Poznyak, E. L., On the stability of shafts beyond the critical angular velocities (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 5, 104–107, May 1957.

Paper discusses the occurrence of instability of rotating shafts according to internal friction theory of shaft whirling. It reviews work done mainly by recent Russian investigators (Leonoff, Bezpalko, Tchaievsky, etc.), who point to discrepancies between experimental results and theoretical predictions of stability criteria, based on two general hypotheses of internal friction forces: the loss of energy as a function of frequency, and as a function of deformation amplitude. Investigators' quantitative relationships for stability, considering work of both surface and internal friction forces during a precession cycle, are shown to be supported by experiments, and restated with a word of caution regarding assumptions. Z. W. Dybczak, Canada

4430. Mansfield, E. H., Flexural vibrations of a thin-walled cylinder of rectangular cross section, *Aero. Quart.* **9**, 4, 331–345, Nov. 1958.

Sinusoidal transverse vibrations of a long box of doubly symmetrical rectangular cross section are studied. Stress function solutions are obtained for the webs and the top and bottom surfaces, so that the effects of shear lag and shear deflection are included. The results are expressed in terms of an effective flexural rigidity which may be determined with the aid of a number of graphs. G. Herrmann, USA

4431. Metzmeier, E., Coupled longitudinal and torsional vibration of shafts (in German), *Schiffstechnik* **5**, 27, 95–96, June 1958.

In some crankshafts with helical gear, combined axial and torsional vibrations arise. Author derives the frequency condition by considering the equilibrium of the internal forces and moments and the elastic deformations. H. Neuber, Germany

4432. Volterra, E., and Zachmanoglou, E. C., On longitudinal waves in an elastic plate, *Proc. Amer. Soc. Civ. Engrs.* **85**, EM I (*J. Engng. Mech. Div.*), Part I, Pap. 1896, 17 pp., Jan. 1959.

Approximate method of computation is given for the dispersion of longitudinal waves in an elastic infinite plate using the method of internal constraints and taking into account second-order terms. Interesting numerical results are included in several diagrams, especially for the magnitudes of the field vectors and their variations over the cross section. A good agreement with Lamb's exact theory is obtained. P. P. Teodorescu, Roumania

4433. Takahashi, S., Vibration of rectangular plates with circular holes, *Bull. JSME* **1**, 4, 380–385, Nov. 1958.

Ritz's method has been employed to find frequencies of vibration of the plate described in title, the displacement being expressed as product of bar solutions satisfying boundary conditions of the plates only. Numerical calculations have been worked out for the plate with one hole in its center and with all edges clamped. From author's summary by D. N. Mitra, India

4434. Kel'zon, A. S., Self-centering and balancing of a rigid rotor rotating in two elastic supports (in Russian), *Doklady Akad. Nauk SSSR (N. S.)* **110**, 1, 31–33, Sept./Oct. 1956.

4435. Bogusz, W., Vibration of turbine foundations during the process of turbine starting (in Polish), *Rozprawy Inz.* **6**, 2, 221–230, 1958.

The example of a foundation assumed to constitute an elastically supported rigid body with three degrees of freedom is used to illustrate the important case of elastic vibration with time-variable vibration forcing frequency.

A system of three differential equations, of which two are conjugate, is represented in the separated form. After some simple transformation, each of the equations of the separated system turns out to be an equation of the same type. By appling the complex variable, the solution of this equation reduces to a Volterra integral equation, enabling an approximate computation of the parameters of vibration. The error may easily be appraised. The method is applied to the case of linearly variable vibration forcing frequency. M. Piatek, Poland

4436. Slibar, A., and Paslay, P. R., The forced lateral oscillations of trailers, *J. Appl. Mech.* **24**, 4, 515–519, Dec. 1957.

See AMR **11** (1958), Rev. 770.

4437. Reipert, Z., Free vibration and buckling of a triangular plate with ribs (in Polish), *Rozprawy Inz.* **6**, 2, 233–252, 1958.

By considering free vibration and buckling of rectangular plates we may, in some cases, obtain solutions for plates in the form of a rectangular triangle. For this purpose we should consider only those forms of vibration and buckling that are antisymmetric in relation to the diagonal line of the rectangle. In such a manner, using multiple trigonometric series, a number of rectangular plates with ribs parallel to the edges and simply supported on the periphery are considered, the problem being reduced to the determination of the zeros of certain determinants.

M. Sokolowski, Poland

4438. Snowdon, J. C., The choice of resilient materials for anti-vibration mountings, *Brit. J. Appl. Phys.* **9**, 12, 461–469, Dec. 1958.

Resilient materials used in vibration isolators sometimes have stiffnesses that are frequency-dependent. For these materials considerable changes of damping and dynamic modulus occur as the frequency is varied. The damping factor becomes a maximum and the dynamic modulus changes most rapidly at frequencies whose periods correspond to relaxation times for the resilient materials. These frequencies are in regions of concern for the vibration engineer for many synthetic rubber-like materials. The transmissibility equation for vibration isolators has been derived assuming the elastic modulus is frequency-dependent. Experimental results have been plotted for isolators where this effect is of importance. It is shown that the stiffness of the mount increases with frequency and that this can result in a relatively large decrease in the efficiency of an isolator.

A compound mounting system is considered which consists of two single-degree-of-freedom systems in tandem. It is shown that, for frequencies that are high compared with either of the natural frequencies of the system, the isolation of the compound system increases more rapidly with frequency than that of a simple system. I. Vigness, USA

4439. Di Taranto, R. A., A blade-vibration-damping device—its testing and a preliminary theory of its operation, *J. Appl. Mech.* **25,** 1, 21–27, Mar. 1958.

See AMR **11** (1958), Rev. 2465.

Wave Motion and Impact in Solids

(See also Revs. 4291, 4421, 4432, 4507, 4767, 4777)

4440. Alekseev, A. S., and Gel'chinskii, B. Ia., Determination of the intensity of head waves in the theory of elasticity by the ray method, *Soviet Phys.-Doklady* **3,** 1, 189–192, Dec. 1958. (Translation of *Dokladi Akad. Nauk SSSR (N.S.)* **118,** 4, 661–664, Jan.–Feb. 1958 by Amer. Inst. Phys., Inc., New York, N. Y.)

K. O. Friedrichs and J. B. Keller discussed the acoustical diffraction, reflection and refraction of a weak spherical or cylindrical shock at a plane boundary of interface [AMR **9** (1956), Rev. 2021]. V. M. Babich used ray method and calculated the intensity of wave front [*Dokladi Akad. Nauk SSSR* **110,** no. 3, 1956]. B. Ia. Gel'chinskii studied head waves in the problem of the reflection and refraction of elastic waves with an arbitrary form [*Dokladi Akad. Nauk SSSR* **118,** no. 3, 1958]. Utilizing these works, authors discuss the intensity and the form of head waves excited at a plane boundary of separation between two elastic media. Incident waves have any arbitrary form, but are assumed to be linearly polarized. Formulas are obtained giving the intensity of various induced waves. One of them can be applied when one of the elastic media is not uniform. Y. Sato, Japan

4441. Chakraborty, S. K., Propagation of waves in isotropic elastic medium generated by forces on the inner surface of a nearly spherical cavity, *Bull. Calcutta Math. Soc.* **49,** 4, 207–215, Dec. 1957.

The problem is the effect of slight departures from sphericity of the cavity on the radiated components of stress and displacement. The deviations from sphericity are expanded in spherical harmonics; boundary conditions at the cavity surface are applied correct to second order in the deviations. The wave field is calculated correct to first order, expanded in combinations of spherical harmonics and spherical Hankel functions.

Results for a pressure source are general to the order of approximation involved. The radial stress wave resulting is derived and plotted. For shear excitation, aximuthal dependence is ignored. Expressions for the aximuthal displacement are derived.

There appear to be no serious errors. A good balance between explanation and algebraic detail make it easily read and suitable for pedagogical purposes. R. Lyon, USA

4442. Gel'chinskii, B. Ia., Reflection and refraction of an elastic wave of arbitrary form in the case of a curved interface, *Soviet Phys.-Doklady* **3,** 1, 186–188, Dec. 1958. (Translation of *Dokladi Akad. Nauk SSSR (N.S.)* **118,** 3, 458–460, Jan.-Feb. 1958 by Amer. Inst. Phys., Inc., New York, N. Y.)

Paper is concerned with the problem of reflection and refraction of nonstationary waves from an arbitrary surface of separation of two elastic media. In particular the zeroth approximation to the displacement fields (leading term of series representation) of the reflected and refracted waves is determined with the aid of the ray method. An expression is given for the intensity of the reflected wave displacement field at a point, say P, in terms of the principal radii of curvature of the wave front surface at a point of incidence, say Q, and the distance along the ray from Q to P.

J. Miklowitz, USA

4443. Sinitsyn, A. P., Dynamic planes of influence for a system with several degrees of freedom (in Russian), Investigations on the theory of constructions no. 7, Moscow, Gosstroiizdat, 1957, 121–134; *Ref. Zh. Mekh.* no. 3, 1958, Rev. 3201.

Planes of influence are evolved for the deflection moments and transverse forces in relation to the single initial conditions, assigned to different points of a beam, as a system with several degrees of freedom. Use is made of the numbers of influence for transfers (that is those values for the arbitrary constant solutions) which are obtained from the unit initial conditions, when, for the last, an introduction is made of only the velocity (in seismic disturbances the actual influence indicates initial acceleration). The plane problem is solved for the dynamic computation of the beams, and actual lines of influence are drafted for the forces in relation to the point of application of the unitary initial velocity; having drawn up a network of lines of influence for different moments of time, author obtains the plane of influence. A valuable example is examined of the drawing up of a plane of influence of forces for a simple girder beam with two point masses in relation to the change of the point of application of the initial velocity.

N. K. Snitko

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4444. Solomon, L., Potential functions of displacement for Lamé's dynamic equations (in Roumanian), *Acad. Repub. Pop. Romine Comun.* **8,** 7, 647–655, 1958.

Two expressions of displacements are obtained with respect to potential functions for the dynamic problem of elasticity, similar to the solutions given by Papcovici and Kom in the static case.

Author shows that the same reasoning may be applied to other ways of expressing elastic displacements, which would, however, result in a reiteration of the same calculus procedure.

Similar solutions were previously deduced by E. Steinberg and R. A. Eubanks ["On stress function for elastokinetics and the integration of the repeated wave equations," *Quart. Appl. Math.* **15,** 2, 149–153, July 1957]. M. Misicu, Rumania

4445. Mazitov, Sh. S., Influence of transverse vibrations on the stresses and forces in a rod during a longitudinal impact (in Russian), *Izv. Otd. Estestv. Nauk Akad. Nauk TadzhSSR* no. 16, 3–13, 1956; *Ref. Zh. Mekh.* no. 3, 1958, Rev. 3214.

Data are furnished of the experiment for the determination of stresses in the mean section of a hinge-supported rod during a longitudinal elastic impact. It appeared that, at the expense of the transverse vibrations, the stresses in the edge fibers, deformed to their maximum, increased by approximately 3%. A theoretical evaluation is given for the energy of the transverse vibrations of a rod. It is shown that this energy also is relatively small, of the order of 1% of the general energy of the impact. As shown in the paper, disregarding the transverse vibrations of the rod during longitudinal impact is justified.

N. F. Lebedev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4446. Motsonelidze, N. S., Simplified dynamic calculation for round arches (in Russian), *Trudi Gruz. Politekhn. In-ta* no. 6 (47), 16–23, 1956; *Ref. Zh. Mekh.* no. 11, 1957, Rev. 13112.

An approximate formula is deduced for the calculations of the basic frequency of the natural vibrations of a round two-hinged arch of variable section, which is being subjected to a hydrostatic load; the frequency values are taken both from the bottom

and from the top of the arch, a matrix computation is adopted. An example is investigated of the calculation for the basic frequency of vibrations of a round two-hinged arch, whose moment of inertia for the transverse section is given by the formula $J_x = J_0/\cos 0.6\varphi_x$ where J_0 is the moment of inertia of the arch's section at the key of the arch. A. I. Oseledko

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4447. Cook, M. A., Mechanism of cratering in ultra-high velocity impact, AFOSR TN 59-50 (Univ. Utah, Inst. of Metals Explosives Res.; ASTIA AD 209 413), 26 pp., Jan. 1959.

The equations of the hydrodynamic theory of penetration of targets by shaped charge jets are presented first in general form. These equations are then expressed in the ideal form and examined by experimental observations. Then a non-ideal theory is presented that takes into account heat losses by compression, shock heating and radiated shock waves. The conditions for impact explosions of targets are then discussed and a theory extended to cover the entire velocity range of impact from the plastic deformation threshold v_σ to well above the impact explosion threshold v_c. Some experimental evidence relating to this more general theory is also presented.

From author's summary

4448. Gamayunov, A. I., Pressure of ice on installations (in Russian), *Transp. Str-vo.* no. 11, 16-18, 1956; *Ref. Zh. Mekh.* no. 3, 1958, Rev. 3291.

Author disputes the formulas for the calculation of ice pressure, proposed by K. N. Korzhavin [see *Tr. Transp. -Energ. -In-ta Zap.-Sib. Fil. Akad. Nauk SSSR*, no. 5, 1955], with the condition that in deflection and in local compression the ice's stability is greater than its volumetric stability. According to the experimental data the stability of the ice in deflection is less than the cubical, while in local compression it is close to the cubical stability. Disputed also is the propagation of the experimental relations, between the velocity of motion and the stability of the ice, obtained at small velocities, to large velocities, at which the ice's behavior is that of a brittle body.

S. A. Sementsov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Soil Mechanics: Fundamental

(See Rev. 4790)

Soil Mechanics: Applied

(See also Rev. 4380)

Book—4449. Szechy, K., Defective foundations [Alapozasi hibak], Budapest, Muszaki Konyvkiado, 1958, 116 pp.

Book deals with a very unusual topic. Failures due to the lack of proper soil investigation, errors in design, improper construction, change of loading conditions and dynamics of nature are treated. More than sixty actual cases are described in logical order. The description of proper soil mechanics analysis and correction of failure in each case makes this book very valuable.

A. L. Simon, USA

4450. Teplitskii, E. I., Simplification of calculations for rigid foundations (in Russian), *Str-vo Predpriyatii Neft. Prom-sti* no. 3, 13-15, 1957; *Ref. Zh. Mekh.* no. 10, 1957, Rev. 12023.

For the calculations for rigid foundations, suitable for stamping machines, located near the surface of an elastic semispace, the proposal is made to divide up the under surface of the stamping machine into several portions, on the assumption that, inside each portion, the active pressure varies in accordance with the linear principle. The intensity of the pressure on each portion is determined from the condition of the equilibrium of the stamping machine and the equality of the settlement of the semispace at several points below the stamping machine. Author sees advantages in his method when compared with the similar method put forward by Zhemochkin [B. N. Zhemochkin, A. P. Sinitsyn, "Practical methods for calculations for foundations of beams and plates erected on an elastic bed, without use of Winkler's hypothesis," Stroiizdat, 1947] in that, in his method, when passing from one portion to another the function of reactive pressure remains continuous and only the first derivative undergoes disruption. The proposal is made to use the method for cases otherwise not classified on the basis of more exact solutions; for instance, for the calculation of soil beds with a complicated form of sole, for the evaluation of the mutual influence on settlement and sag of two adjoining rectangular stamping machines, etc.

Results are given for the calculation of some examples, with an estimate of the solution's accuracy. The paper does not contain tables and directives for practical calculations.

M. I. Gorbunov-Posadov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4451. Karafiath, L., An analysis of new techniques for the estimation of footing sinkage in soils, U. S. Army Ordnance Corps, Land Locomotion Research Branch, Research & Development Division, OTAC Rep. 18, 32 pp., Oct. 1957.

The problem is primarily one of calculating the probable sinkage depth of off-road vehicles, such as trucks and tractors, and is of particular interest to designers of such equipment.

Equations for sinkage of vehicles in sand are developed, based on the theory of plastic flow but modified by empirical constants. The Terzaghi equation for bearing capacity of footings, including surcharge, is used, and the shearing resistance of the surcharge is included. Modifications are applied to account for initial elastic deformation. Equations are developed for the axially symmetrical case of loaded plates. Tests on circular plates up to 5 inches in diameter, in both loose and dense sand, checked the equations.

The analysis represents an advance in the techniques of determining settlement of off-road vehicles and of footings loaded beyond the elastic limit of the soil.

F. J. Converse, USA

4452. Krochmer, V. V., Methods for calculation of channel walls as elastic structures and with consideration for the compressibility of the soil in the region of the wall unions (in Russian), *Trudi N.-i. In-ta Osnovania i Fundamentov* no. 30, 74-110, 1956; *Ref. Zh. Mekh.* no. 11, 1957, Rev. 13209.

The calculation for the strength and shift on a channel wall, loaded with earth filling, in the presence or absence of an anchoring strengthening. The top portion is taken to be loaded with the active pressure of the filling. The lower is looked upon as a rod elastically fastened in an elastic semi-space. The contact problem for an elastic rod and semi-space is solved, while the rod at the surface of the semi-space is loaded with a horizontal force and with a moment replacing the action of the filling. The disruption of the continuity of the semi-plane, brought in by the body of the rod, is not taken into account. The friction between the soil and the channel is disregarded. For the determination of the stresses in the semi-plane the formulas of Melan are applied in their corrected form evolved by the abstractor [M. I. Gorbunov-Posadov, O. Ya. Shekhter, V. A. Kofman, *Trudi N.-i. In-ta Osnovanii i Fundamentov* no. 24, 39-80, 1954]. The shifts are established in conformity with the formulas cited in the same paper. The con-

tact condition—the equality of the relative horizontal shifts—is only applied at three points. This gave the author the possibility of freeing the computer from the necessity of having to solve the systems of equations. The plastic deformation in the soil near the upper part of the elastic union is disregarded. However it is recommended to establish the depth of the foundation of the channel, because of the requirement that the region where the reactive pressure exceeds the passive pressure of the soil (taking into account the influence of cohesion) should not spread higher than a quarter of the length of the portion of the elastic union. It is assumed that the lower end of the channel, taken to be free in the basic calculation, because of the resistance of the semi-plane, practically does not shift or turn. Consequently it is proposed to determine the reaction of the anchorage strengthening as the reaction of the immovable support of a beam, closed at the lower end and loaded with an active pressure in the upper, and a reactive pressure in the lower, portion. M. I. Gorbunov-Posadov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Book—4453. Press, H., Dams and hydroelectric power plants, Part I: Storage dams (Stauanlagen und Wasserkraftwerke, Teil I: Talsperren), 2nd enlarged ed., Berlin, Wilhelm Ernst & Sohn, 1958, xii + 395 pp. DM54.

New edition (1st ed. 1953) includes description of recent dam structures, built and proposed, with emphasis on the progress. Bibliography is extended to 1233 publications, although some references of importance, especially to dams in the United States, should be added. The book is one of the best publications on this subject. Reviewer believes that better credit should be given to engineers who originated new principles of greater safety and economy. Great number of illustrations (671) is instrumental in better understanding. Less concern is given to calculation methods and model testing which is being used for larger dams. However, photoelastic stress analysis of dams is mentioned (p. 66), now being used in author's institute at the technical university in Berlin. This is the only method of determining gravity stresses at the boundaries of dams (originated in 1940 in the Engineering Materials Lab., University of California, Berkeley).

Following subjects are thoroughly presented and discussed: General conditions of dams, such as reasons for construction, location and required dimensions, effects and selection of the type, considering the soil conditions. Exterior forces. Various types of dams and their basic characteristics (gravity dam, gravity dam combined with arch effect, multiple-arch dam, shell and dome dam, with and without special piers, dam with increased height, repairs and strengthening of dam, underground dam. Special chapter deals with earth-filled dam, advantages and disadvantages of various types, their design and construction, provision of temporary flow, inspection and checking for reliable safety.

J. J. Polivka, USA

Processing of Metals and Other Materials

(See also Revs. 4324, 4356)

4454. Johnson, W., Experiments in the cold extrusion of rods of non-circular section, *J. Mech. Phys. Solids* **7,** 1, 37–44, Nov. 1958.

Paper briefly describes continuing experiments in the extrusion of pure lead and tellurium lead rods of circular, square, rectangular, triangular and I section, and the investigation of the effects of section shape and punch speed on the necessary extrusion load. It is shown that, for a given reduction in area, load is independent of section shape for all but re-entrant shapes, and increases with increase in extrusion speed. Pertinent observations:

(a) With the two kinds of lead, the true extrusion load is fairly clearly definable, i.e., the coring point is easily identifiable, and it is true to say that for all the shapes with the exception of the I section, which are convex and comparatively squat sections, the load is independent of the shape and wholly dependent on the reduction in area within the limits of experimental repeatability.

(b) The I section or re-entrant shape requires, in these experiments, a 5–10% higher load than does the squat section of the same reduction. A small number of tests with unlubricated specimens on the 0.75 reduction shapes increased the load in all cases by 6–8%.

(c) Aluminum true extrusion pressures are not so easy to derive from an autographic diagram, especially for the smaller reductions, since the coring point is not clearly in evidence. It will be observed from the autographic diagrams for superpure aluminum that not only is the coring point indistinct so that it is difficult to define precisely what the extrusion pressure is, but also that the diagram shape changes slightly with the form being extruded. The point remains, however, that the load does not significantly alter with changes in squat section shape.

It appears to this reviewer that the incompletely described geometry, especially concerning the differences between re-entrant and "squat" shapes, may be masking possibly significant differences in the results. C. C. Osgood, USA

4455. Fukui, S., Yuri, H., and Yoshida, K., Analysis for deep-drawing of cylindrical shell based on total strain theory and some formability tests (in English), *Aero. Res. Inst., Univ. Tokyo* **24,** 3, 43–75, June 1958.

Professor Fukui and his co-authors have considered the problem of deep-drawing both for conical and flat dies. Their theoretical analysis is based on the Hencky relations (using total rather than incremental strains) and both power law and linear work-hardening functions are used to describe the stress-strain characteristics of the material. Comparison is made with experimentally measured strain distributions and punch forces, reasonably isotropic phosphor bronze sheet having been used in the tests. Good agreement is claimed. Further investigations are described in which the effects of different stress-strain characteristics on resulting stress and strain distribution and on deep drawing limits are assessed.

This is an interesting paper, written in good English, but reviewer found many deficiencies. For example, the list of symbols given is incomplete and, although extensive experimental work was carried out using a conical die, reviewer could nowhere find the actual value of the conical angle of the die. As this is an important parameter in the original equations developed it would be a difficult matter to repeat any of the authors' calculations. Also, since the final equations have to be solved numerically, reviewer wonders why the total strain theory was used rather than a more realistic "flow"-type theory.

Reviewer found it astounding that in a list of ten references to previous work dating back to 1926 there is no mention of the extensive theoretical and experimental work by Professor H. W. Swift of Sheffield University, and his colleagues. This is exemplified in the theory developed by Fukui and his colleagues in that no mention is made of the very important phenomenon of thinning due to plastic bending under tension over the die and punch profile radii. Neglect of this effect may account in part for some of the lack of agreement between their calculated and experimental thickness strains. To be fair, the authors do make the following statement: "It should be pointed out that the actual thickness adjacent to the flange center and the portion in contact with the die shoulder is less than the calculated value because

of the assumption of the blank holding force acting only around the periphery of the flange portion and zero stress ($\sigma_3 = 0$) over the remaining body and for the neglection of the effect of bending in the part in contact with the radius of the die shoulder." This neglect of Swift's work makes it difficult to assess the authors' work. In general, it would appear that the agreement between their experimentally and theoretically determined strains is less good than was shown in Professor Swift's researches.

In their introduction, the authors state that there is very little in the way of bibliography; this is certainly not true; for example, apart from Chung and Swift's work, much has been done at B.I.S.R.A. on the effect of wrinkling (B. W. Senior), and by D. A. Barlow of Aluminum Laboratories Ltd. on deep drawing and forming limits. This work has all been published in accessible journals, but has not been mentioned by the present authors. Similarly it is stated in the summary that "It is revealed that the strain distributions over the flange regions are nearly independent of sheet material." This fact had already been clearly demonstrated by Chung and Swift. J. M. Alexander, England

4456. Fukui, S., Yoshida, K., and Abe, K., Deep drawing of cylindrical shell according to the so-called hydroform method (in English), *Aero. Res. Inst., Univ. Tokyo* **24**, 4, 77–98, June 1958.

This is a companion on paper to preceding review and describes experimental and theoretical work undertaken to elucidate the deep drawing of cylindrical cups in the case where the usual metal die is replaced by a fluid which exerts a hydrostatic pressure on the deforming blank. An analysis similar to that described in the companion paper (based on the Hencky relations) was used and good agreement found between theory and experiment.

It was found experimentally that the fluid pressure required was conditioned by fracture due to excessive "blank holding pressure" on the one hand, and formation of flange or body wrinkles on the other. Effective flange lubrication was found to be very important to reduce the high frictional resistance there. The effect of the applied hydrostatic pressure was found to be beneficial in increasing the drawing ratio attainable, before fracture, in spite of increased drawing stresses due to the high flange friction. This effect was attributed to "locking" of the side walls of the cup on to the punch, thus inhibiting the onset of fracture which occurs in the usual deep-drawing process. Depending on the fluid pressure, in fact, the authors suggest that three types of fracture are possible:

(1) Fracture at the corner of the punch profile radius
(2) Fracture along the side wall
(3) Fracture at the "forming radius."

This is a very interesting and useful contribution to a subject about which there is little fundamental information. One small criticism is that the fluid used in the experimental apparatus was not described; at least, the reviewer could find no reference to it.
J. M. Alexander, England

4457. Johnson, W., and Woo, D. M., Pressure for indenting material resting on rough foundation, *J. Appl. Mech.* **25**, 1, 64–66, Mar. 1958.

See AMR **11** (1958), Rev. 2643.

4458. Simms, R. B., Automatic gauge control in rolling mills, *J. Inst. Metals* **86**, 289–302, 1957–58.

4459. Woo, D. M., On the variation of tension in stretch-forming a metal strip, *J. Appl. Mech.* **25**, 4, 623–624 (Brief Notes), Dec. 1958.

4460. Hantos, R., Heeringer, J., and Schey, J., Investigation of forces produced by tube drawing (in Hungarian), *Magyar Tud. Akad. Musz. Tud. Oszt. Köz.* **21**, 1/4, 141–155, 1957.

Fracture (Including Fatigue)

(See also Revs. 4350, 4372, 4401, 4448, 4483, 4513)

4461. Demer, L. J., Interrelation of fatigue, cracking, damping, and notch sensitivity, WADC TR 56-408, (ASTIA AD 118-157), 151 pp., Mar. 1957.

This report is the fourth in a series dealing with the general subject of fatigue cracking.

Rotating bending fatigue tests at 20 rpm on seven materials, in the unnotched and in the notched condition, are described. Although the aim was originally to investigate the existence of relationships between damping, elasticity, fatigue strength and notch sensitivity, and to follow the variation of the damping and stiffness properties of the specimens during the test, authors have added to this some interesting observations on initiation and propagation of macrocracks and on the methods for detecting these initiating cracks.

The dependence of the specific damping energy on stress and number of cycles is established and an explanation is given for the differences in behavior between different materials. Below some stress level beyond 0.5 of the fatigue-limit or long-life fatigue strength, damping is independent of the number of cycles; above this stress level damping depends on the number of cycles and increases more rapidly with stress than was the case for lower stress values. In notched specimens initiation of cracking could be detected, generally with good accuracy, by an increase in deflection; at the same time a decrease in damping was observed.

Test results are fully exploited and their interpretation is facilitated by a large number of graphs.
R. Dechaene, Belgium

4462. Filimon, I., Considerations on the breaking of reinforced-concrete caissons under bending moments (in Roumanian), *Rev. Construct.* **10**, 12, 594–601, 1958.

Structure was lightly reinforced and consequently damages occurred in places with maximum bending moments. Tests were carried out on three caissons and the results were compared with theoretical analysis. It was proved that insufficient reinforcement of 2-in. slabs framed in 2 × 5-in. ribs and its placemen were responsible for the failure. J. J. Polivka, USA

Experimental Stress Analysis

(See also Revs. 4283, 4382, 4399)

4463. Williams, M. L., Jessey, M. E., and Parmerter, R. R., Some exploration photoelastic studies in stress wave propagation, Guggenheim Aeronautical Lab., Calif. Inst. Technol. N123-605305-3825a: T.O. 1, GALCIT 90, 36 pp., Oct. 1958.

During the past three years the Guggenheim Aeronautical Laboratory of the California Institute of Technology (GALCIT) has been conducting a photoelastic study of stress wave propagation in solids, using a high-speed framing camera.

This paper presents a technical description of the camera, now operating at 100,000 35-mm frames per second at one-tenth-microsecond-exposure time for an elapsed time of approximately two milliseconds. The design capability is expected to approach a half million frames per second. This equipment has been used to record dynamic photoelastic stress fringe patterns in various specimens under impact loadings. Typical experimental records of wave propagation in cracked plates, layered media, compressed bars and beams, and cross sections of rocket heads are included in this report. From authors' summary

4464. Preda, N., Bausic, V., Horbaniuc, D., and Marinescu, M., Photoelastic study of the stress state in simply supported beams with linearly varying heights (in Roumanian), *Bul. Inst. Politebnic Iasi* **8**, 1/2, 395–400, 1958.

Photoelasticity results are presented for the stress distribution in simply supported beams with linearly varying height. Authors show that (1) the value and the distribution of normal stresses are close to these obtained through Navier's formula and (2) the value and the distribution of tangential stresses differ sensibly from those obtained through Juravsky's formula.

R. Priscu, Roumania

4465. Balan, St., Rautu, S., and Petcu, V., Studies on the behavior of structures in the elastic-plastic range by means of chromoplastic models (in Rumanian), *Rev. Construct.* **11**, 1, 18–20, Jan. 1959.

Article presents a new method for investigating the behavior of structures in the elastic-plastic range. Models on a reduced scale are made of chromoplastic materials whose properties make it possible to follow in a visual way the zones where plastic deformations occur, the evolution of such zones, the forming of plastic joints, the breaking process and the varying capacity of the structure, without any special apparatus.

The experimental results agree in a satisfactory manner with the theoretical analysis. From authors' summary

4466. Tramposch, H., and Gerard, G., Physical properties of plastics for photothermoelastic investigations, *J. Appl. Mech.* **25**, 4, 525–528, Dec. 1958.

The optical and physical properties of Paraplex P43, Castolite, and epoxy resin Hysol 6000-OP, which are potentially of interest in photothermoelastic investigations, were investigated over a temperature range from +100 to −60 F. Results on the thermal-expansion coefficient, the material fringe value, and the modulus of elasticity as functions of temperature are presented. Also evaluated were thermal properties of importance in heat conduction. Photothermoelastic figures of merit, which rate the optical sensitivity of materials in photothermoelastic applications, as well as a new method to determine this figure in a relative manner are presented.

From authors' summary

4467. Sukhomel, E. G., The accuracy of stress determinations in the parts of metallic structures by means of wire strain gages (in Russian), *Trudi Kievsk. Gidromelior. In-ta* no. 5, 157–163, 1956; *Ref. Zh. Mekh.* no. 11, 1957, Rev. 13639.

Results are given of the investigation of error occurring when measuring static deformations by means of wire strain gages in an unbalanced bridge with constant current with readings taken with a mirror galvanometer. The error, characterizing the inaccuracy of the arrangement, made up 16% of the error due to inaccuracy in the preparation and bonding of the strain gages. A recommendation is made that at least twenty out of every batch of gages should be tested for determination of the quadratic error in measurements. In order to reduce error small beam calibration is recommended, the beam being made of the same material as the object under test. M. M. Belyaev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Material Test Techniques

(See Revs. 4357, 4401)

Properties of Engineering Materials

(See also Revs. 4352, 4353, 4354, 4412, 4416, 4448, 4466, 4492, 4504, 4675, 4814)

4468. Onaran, K., Testing of the mechanical properties of constructional steel (in English), *Bul. Istanbul Tekn. Univ.* **11**, 1, 29–44, 1958.

This paper presents test results on the mechanical properties of Karabuk steel products. Materials, testing apparatus and test procedures are described briefly; the results are shown in tables and are discussed. From author's summary

4469. Semirog-Orlisk, V. N., Mechanical properties of case-hardened test samples determined by the method of all-sided irregular compression in relation to the thermal treatment and structural condition (in Russian), *Sb. Trudi In-ta, Stroit. Mekhan. Akad. Nauk USSR* **22**, 56–69, 1956; *Ref. Zh. Mekh.* no. 11, 1957, Rev. 13596.

Results are given for the investigations of the mechanical properties of case-hardened test samples in relation to their carbon content in the top layers, to the structural condition, obtained in given conditions of thermal treatment and case-hardening. In the determination of the mechanical properties the method of all-sided irregular compression was adopted.

From author's summary
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4470. Botaneli, A. I., Temperature dependence of hardness of steel (in Russian), *Fiz. Metallov i Metallovedemie* **3**, 3, 540–546, 1956; *Ref. Zh. Mekh.* no. 11, 1957, Rev. 13572.

Results are given of the determinations of the temperature dependence of the hardness of constructional, instrument, and high-speed cutting steels by the static method of die-stamping at temperatures of up to 1250°. An explanation is furnished of the features of the curves of the thermal relations of hardness.

From author's summary
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4471. Pavlov, V. A., Kryuchlov, N. F., and Fedotov, I. D., The temperature relationship of the modulus of elasticity of alloys of a hard solution of aluminum with magnesium (in Russian), *Fiz. Metallov i Metallovedenie* **3**, 3, 555–557, 1956; *Ref. Zh. Mekh.* no. 11, 1957, Rev. 13578.

Measurements for the modulus of elasticity are given for pure aluminum and some of its alloys with magnesium in the temperature range from 77 to 680 K.

From authors' summary
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4472. Hall, R. W., and Sikora, P. F., Tensile-properties of molybdenum and tungsten from 2500° to 3700° F, *NASA Memo* 3-9-59E, 30 pp., Feb. 1959.

Specimens of wrought sintered tungsten, arc-cast unalloyed molybdenum, and a molybdenum alloy containing 0.5 percent titanium were fabricated from 1/2-inch-diameter rolled or swaged bars. Tensile test equipment described herein was used to evaluate the specimens both in the as-received condition and after a 30-minute recrystallization anneal at 3800 F. Two as-received tests were also made on an experimental molybdenum alloy containing 0.46 percent titanium and 0.07 percent zirconium. Results show that tungsten was considerably stronger than the molybdenum specimens over the temperature range specified. Differences in the fracture ductility were also observed.

From authors' summary

4473. Waters, W. J., Signorelli, R. A., and Johnston, J. R., Performance of two boron-modified S-816 alloys in a turbojet engine operated at 1650° F, *NASA Memo* 3-3-59E, 30 pp., Mar. 1959.

In conjunction with engine testing, various laboratory tests were performed upon S – 816 + B. These included stress-rupture tests at 1650 F and tensile and impact tests at both 1650 F and room temperature. Although laboratory tests indicated the alloys had adequate physical properties for engine use, buckets of both alloys failed after relatively short periods of engine operation (first failures at 10 hr). All bucket failures were caused by mechanical fatigue or impact damage. Engine impact studies revealed no apparent relation between the size of the failed bucket fragment and the resulting impact damage.

From authors' summary

4474. Stern, E. G., Better utilization of wood through assembly with improved fasteners, *Virginia Polytech. Inst., Wood Res. Lab. Bull.* no. 38, 44 pp., Apr. 1959.

Improved wood assemblies, components, and structures have been developed in the U.S.A. as a result of the availability of improved fasteners. They include bright and hardened nails having annular or helical threads, wood screws of improved design, sheet-metal nails, and other sheet-metal connectors. Their introduction and the use of improved nailing procedures have resulted in better and more economical utilization of wood for the benefit of both producer and consumer. It is the purpose of this paper to bring the potentialities of this advanced status of wood assembly and construction to the attention of those who are not aware of it and who may benefit by becoming familiar with it.

From author's summary

4475. Chiarito, P. T., and Johnston, J. R., Experimental evaluation of cermet turbine stator blades for use at elevated gas temperatures, *NASA Memo* 2-13-59E, 25 pp., Feb. 1959.

Cermet blades were successfully subjected to 100-hr endurance tests at normal gas temperatures in a turbojet engine in order to evaluate two methods for mounting them. The method of support considered best for high-temperature operation was then used to mount a group of four cermet blades. This group was subjected to an average turbine-inlet gas temperature of 2000 F. Thermal distortion of the spacer band of the nozzle diaphragm might have caused the premature fracture of one cermet blade after 52 hrs. Improved design of a service engine should preclude such failures.

From authors' summary

4476. Knapp, W. J., and Shanley, F. R., Ceramic materials—properties for structural applications, *Aero/Space Engng.* **17,** 12, 34–38, Dec. 1958.

Elevated temperatures now make impractical the use of common structural materials in certain parts of aircraft, gas turbines, and rocket engines. A solution is the use of ceramics.

From authors' summary

4477. Piganiol, M. P., Molecules and new plastic substances (in French), *Mem. Soc. Jngrs. Civ., France* **111,** 5, 373–383, Sept.–Oct. 1958.

Improvements in our knowledge concerning the relations between the detailed architecture of the giant molecules and the macroscopic properties of the objects they form have made it possible to develop new plastics of highly valuable properties, likely to meet the most severe requirements (resistance to high temperatures, elimination of static charges, dirt-proof fabrics).

The elements of the recently discovered relations forming this combination "structure-properties" are reviewed.

From author's summary

Structures: Simple

(See also Revs. 4275, 4351, 4374, 4379, 4443, 4446)

Book—4478. Torroja, E. (translated from original Spanish by J. J. and Miles Polivka), Philosophy of structures, Berkeley, Univ. of Calif. Press, 1958, 366 pp. $12.50.

Book was obviously written for general reading in the fields of art, architecture and civil and structural engineering with an accent on the last mentioned. To this end it is a well-prepared document and places high on the recommended reading list. Throughout the volume the reader will be fascinated by the perplexing and underlying thoughts fostered by the author's words and phraseology. There will be both agreement and disagreement with the various statements and inward meanings which can be envisaged as the author's sincere intent.

Certain conflicts are apparent, such as those between the artist, architect and structural designer; also between aestheticism, structural properties and the ever monstrous subject of cost which seem to have almost compelled the author to prepare this volume. His treatise is an attempt to dispel these conflicts, arguing that understanding is gained through the educational and exposure processes. The underlying and basic ideal of popular education is commendable but only through the preparation and assimilation of many more works will there develop any widespread and true appreciation of the meaningfulness of philosophy in structures.

S. Barradale, USA

4479. Vesselovsky, G. V., Analysis of a continuous beam with a circular axis (in Russian), *Nauch. Trudf Novocherkassk. Politekhn. In-ta* **29,** 43, 52–64, 1955; *Ref. Zh. Mekh.* no. 8, 1957, Rev. 9497.

Open, curved, continuous beams are analyzed by means of a system of equations of the six moments at the supports. A beam with an axis following a circular arc is analyzed in the same manner as a rectilinear, continuous beam.

Formulas are given for calculating the coefficients of the system of equations of the six moments. The question of most efficient calculations of the free terms is not touched on. Simplified expressions are given for the case of regularly-spaced supports.

The method described is applicable only to circular-arc beams carried on an odd number of supports.

Yu. P. Grigor'ev

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

4480. Fok, T. D. Y., and Au, T., Numerical analysis of two-hinged arches, *Proc. Amer. Soc. Civ. Engrs.* **84,** ST 5 (*J. Struct. Div.*), Part I, Pap. 1758, 10 pp., Sept. 1958.

Authors' synopsis describes the content of the paper properly as intending to offer, on the basis of a known method of analysis, a standardized form of systematic numerical calculations for two-hinged arches of variable cross section.

K. Arnstein, USA

4481. Czerniak, E., Rigid frame analysis with the aid of digital computers, *Proc. Amer. Soc. Civ. Engrs.* **84,** ST 3 (*J. Struct. Div.*), Pap. 1634, 31 pp., May 1958.

After general comment on the analysis of highly indeterminate structures (reviewer diasgrees with author's statement that "With the introduction of the Cross method of moment distribution the number of simultaneous equations was reduced to the number of independent joint translations"), a two-bay unsymmetrical gabled frame and a four-bay lean-to frame with tapered roof members are analyzed and the "slope-deflection" and equilibrium equations are arranged simultaneously in matrix form in such a way that load constants are accumulated in the left hand side of the equations. The solution of that matrix, for which the use of digital computers

is proposed, gives not only end-moments, and vertical and horizontal shear, but also joint rotation and column deflections.

Reviewer thinks the proposed method might confuse non-specialists and does not bring any novelty to practical or theoretical applications. E. P. Villarreal, Argentina

4482. Izraelit, A. B., Calculations for statically indeterminate thin-walled constructions by the method of given forces and stresses (in Russian), *Trudi Vses. Zaochn. Lesotekhn. In-ta* no. 2, 167–173, 1956; *Ref. Zh. Mekh.* no. 11, 1957, Rev. 13318.

Making use of the mathematical analogy between the differential relations of compressed-deflected and of thin-walled rod systems, author extends to the latter the method of given moments and stresses. A. K. Mroshchinskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4483. Wierzbicki, W., Probabilistic and semi-probabilistic method for the investigation of structure safety (in English), *Arch. Mech. Stös.* **9**, 6, 685–694, 1957.

A method is presented for the determination of safety factors based on the calculus of probability. Two methods are explained:

(1) The probabilistic approach in which the required stress coefficients are random in nature, and

(2) The semi-probabilistic approach in which the stress coefficients are based on general equations of the theory of elasticity or other fields of structural mechanics.

Reviewer believes that the method has merit; however, it is the reviewer's opinion that, for the method to be extensively used by the practicing engineer, examples of application of the method to practical everyday cases would be required. C. B. Matthews, USA

4484. Yu, C. W., and Hognestad, E., Review of limit design for structural concrete, *Proc. Amer. Soc. Civ. Engrs.* **84,** ST 8 (*J. Struct. Div.*), Pap. 1878, 28 pp., Dec. 1958.

The development of limit design of reinforced-concrete structures is reviewed. Various theoretical approaches are discussed, and emphasis is placed on their relative merits. Codes of practice of countries recommending limit design are quoted. The importance of incorporating limit design into future United States practice is stressed, and approaches toward this aim are suggested. From authors' summary

4485. Parme, A. L., Practical aspects of ultimate strength design, *Proc. Amer. Soc. Civ. Engrs.* **84,** ST 5 (*J. Struct. Div.*), Part I, Pap. 1757, 22 pp., Sept. 1958.

Time-saving design charts for the rapid selection of the critical-load-factor combination are presented. Paper also includes studies comparing the loads and area of reinforcement as obtained by the ultimate-strength procedure to that obtained by conventional methods. From author's summary

4486. Zaslavsky, A., Safety factor in structures in the elastic range without stress-load proportionality, *Bull. Res. Counc. Israel* **6C,** 2, 135–142, Feb. 1958.

Paper deals with elastic design of structures having no stress-load proportionality. It is suggested that these structures be designed on the basis of the load producing a critical stress, rather than on the conventional basis of the admissible stresses. The suggested method ensures the intended required safety factor against the appearance of the critical stress (for instance, yield stress). From author's summary

Book—4487. Neumann, G., Practical calculation of reinforced concrete [Calcolo pratico del cemento armato], 2nd revised and enlarged edition, Rome, Edizioni Cremonese, 1958, xii + 280 pp. + 76 ill. + 20 photos + 16 tables. L. 3200.

Author, one of the leading Italian specialists in reinforced and prestressed concrete and of international reputation, presents thorough information on concrete as structural material, with emphasis on recent improvements and applications (shells, domes and other space structures). Part I treats characteristic properties of the materials, nature and proportioning of mixes and their control, inspection before and after concreting, testing. Part II refers to design and calculations, including details and specifications, of various structural types and members, such as foundations, columns and pilasters, floors, beams, frames, arches, roofs, shells, domes, etc.

Simplified theories of calculation are presented, accompanied by numerical examples and tables.

Various admixtures and their properties are discussed and full information presented on lightweight concrete and its aggregates, precast and prepacked concrete, and various construction methods. Special attention is given to floors with hollow blocks, introduced in Italy by the author half century ago. Also monolith combination of three materials—concrete, steel and glass (glass-concrete)—and its advantages are described, which in many books on modern concrete structures is overlooked. Many of the mentioned structures were designed and supervised by the author. J. J. Polivka, USA

4488. Matildi, P., Calculation of reinforced-concrete silos with rectangular bins (in Italian), *G. Gen. civ.* **96,** 3/4, 214–229, Mar./Apr. 1958.

After critizing the methods suggested previously by Ritter and later by Palen for designing the walls of rectangular reinforced-concrete silos, in which the problem is simplified by assuming isolated bins, author shows the considerable error involved in case of groups of contiguous cells with side ratios differing from 1, when continuity is disregarded. To eliminate this inconvenience the necessary elements for a more rigourous calculus are presented, with a complete analysis of influences of various factors affecting moment distribution, such as side ratios, wall thickness, taper dimensions at joints, number and arrangement of bins in a group and loading conditions. A valuable list of numerical coefficients is given to permit a rapid and simple moment computation considering various kinds of group arrangements, side ratios from 1 to 1.5 and a fixed proportion of taper at joints. Finally, an example of a silo in construction is presented; although author recommends the reinforcement disposition indicated in detail as very practical, reviewer thinks the simple lapped splices of reinforcing bars just at the region of maximum moment are not safe enough. I. Wolff, Brazil

4489. Kopycinski, B., Theoretical and experimental views of loading capacity of reinforced concrete girders (in Hungarian), *Magyar Tud. Akad. Musz. Tud. Oszt. Köz.* **21,** 1/4, 75–93, 1957.

4490. Eidel'man, S. Ya., Experiments in situ on the natural stresses of concrete (in Russian), *Izv. Vses. N.-i. In-ta Gidrotekhn.* **56,** 71–80, 1956; *Ref. Zh. Mekh.* no. 11, 1957, Rev. 13451.

The natural stresses of blocks of concrete $2 \times 4 \times 6$ m were experimentally determined. Good congruence was established when computing the temperature curves by A. V. Belov's method [*Izv. Vses. N.-i. In-ta Gidrotekhn.* **47**] and taking account of the exothermy of the cement. The modulus of elasticity of the concrete, obtained from the results of tests on a cylindrical sample cut out of a block, was found to be considerably smaller than the modulus determined in laboratory experiments, which can be explained by the different conditions prevailing in the consolidation and hardening of the concrete. The calculated stresses in different points, made with true modulus of elasticity of the concrete, proved to be significantly higher than those measured. In

order to correlate the theoretical and experimental results consideration was given to the phenomenon of stress relaxation.

A. E. Desov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4491. Trojanovic, M., Restrained concrete arch and its stress regulation, Parts I and II (in Croation-Serbian), *Năse Gradevinarstvo* **12**, 7, 147–153, Aug. 1958; **12**, 8, 176–184, Sept. 1958.

Part I. Basic concept, purpose and principles of stress compensations originated by E. Freyssinet (bridges in Moulins, 1906, Veurdre, 1909, Boutiron, 1911), and retrospective review of later development and use of these important and intricate problems, with reference to current technical literature. Author explains that these problems should be solved under consideration of plastic flow of concrete, since the creeping of concrete affects, to a very considerable degree, the state of stresses in the arch, caused by various parasitic influences. It is emphasized that the classical theory of design, based on perfectly elastic properties of materials involved is to be investigated and improved. Thorough discussion of the expansion methods and their optimum conditions is given. Special attention is paid to arches with box sections, thin slabs and ribs. Limiting values of tensile stresses are proposed, especially in sections with low percentage of longitudinal reinforcement. A number of examples and the results achieved are given, especially with reference to Freyssinet's bridges.

Part II. Selection of most convenient moments in concrete arches is discussed and stress compensation and its effects are compared with typical methods of prestressing. Bresse's expressions (1854) are derived and analyzed, and explanation is given why the procedure on the site is based on calculated deformations, using exact modulus of elasticity, the values of which are to be determined by special methods.

J. J. Polivka, USA

4492. Kopycinski, B., Technology of vacuum-concrete (in Hungarian), *Magyar Tud. Akad. Musz. Tud. Oszt. Kõz.* **21**, 1/4, 229–242, 1957.

Paper deals with the effects of vacuum technique on concrete. It contains data relative to the degree of vacuum in different layers of the concrete, the amount of water sucked away, the settling of the concrete and its density. It also deals with the increase of strength of concrete and the savings of cement by vacuum. Author describes a proposition relative to the optimal cement content and the water/cement factor. Using the Feret formula, author analyzes the calculation of vacuum-concrete constructions and proposes a new formula. A. Erdely, Argentina

Book—4493. Sosis, P. M., Calculations for frames by the method of redistribution of the initial values of the unknowns, 2nd edition (in Russian), Kiev, Gostekhizdat USSR, 1956, 168 pp. + illus. 3r 75k; *Ref Zh. Mekh.* no. 11, 1957, Rev. 13292.

An exposition of the theory and application (by means of a series of numerical examples) of the method of calculation for plane frames by distribution of the angles of rotation of the joints. The method is linked and often shows good coincidence with the known Cross method (distribution of moments). At the basis of the method lies not only the book by N. M. Bernadskii ["Symbolic calculation for rigid rod systems," 1929] but also the iterational processes for the systems of equations by I. Ya. Shtaerman ["Method of successive approximations in structural mechanics," 1929]; the work of A. I. Pogozhev should also have been cited ["Method of successive approximations in application to the calculations of multi-span frames." *Trudi VISU* 21–45, 1931], the main idea of which is retold by the author on pp. 35–37 (of his publication), though the system of calculation accepted (by him) differs somewhat from that recommended by Pogozhev. The difficulties met with in the method of angular foci when there are closed contours present in the frame are got round by the author by dismembering the frame into sections with no contours. For frames having transferred joints an original method is recommended of using the combined basic system (with fastenings and hinges) and the application of several cycles of successive approximations. The book may be of use for engineer-constructors and students. I. K. Snitko

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4494. Rozenblat, G. I., Application of the method of deformation for the calculations of frames beyond the limit of elasticity (in Russian), Investigations in the theory of constructions no. 7, Moscow, Gosstroiizdat 1957, 299–314; *Ref. Zh. Mekh.* no. 3, 1958, Rev. 3240.

A method is investigated for the calculations of redundant frames, made up of beams of rectangular section, in the case where the frame is loaded beyond the limit of elasticity. The proposed method takes into account approximately the influence of the elastic-plastic zones, viewed as portions with variable stiffness, on the curve of deflection moments and on the calculable transpositions, which are determined with the aid of Mohr's integrals. It was shown that in these calculations it is important, in a suitable manner, to select a statically determinable system for the drawing of the curves from the unitary force. A concrete example is examined of the calculations for a two-storied (six times statically indeterminable) frame at three different stages of loading, which correspond to one, three and five plastic articulations. In Fig. 3.b instead of $P_{1\,max} = P_{max\ y}$ there should be $P_1 = 1.5\ P_{max\ y}$. N. M. Sapozhkov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4495. Wang, C.-K., Matric formulation of slope-deflection equations, *Proc. Amer. Soc. Civ. Engrs.* **84**, ST 6 (*J. Struct. Div.*) Pap. 1819, 19 pp., Oct. 1958.

Besides deriving the equations, author gives rules for applying the method, illustrated by three numerical examples. The suggested procedure may be preferable to other more familiar methods in the analysis of complex rigid frames under many loading conditions, especially if an electronic computer is available.

A. Werfel, Israel

4496. Chen, L.-K., and Li, S. P., Analysis of rigid frames by successive replacement, *Proc. Amer. Soc. Civ. Engrs.* **84**, ST 5 (*J. Struct. Div.*), Part I, Pap. 1761, 18 pp., Sept. 1958.

An analytical method is developed for the calculation of moments at the supports or joints of rigid frames by replacing a portion of a structure with a member of its equivalent in stiffness or in rigidity. The derivation of formulas in this paper is based on the concept that when a member continuous over several supports or rigid joints is cut at any of its supports or joints the equilibrium of the two portions of the member is unaltered if the slope at the section is preserved. Thus either its left or its right portion can be replaced by any such torsion or flexure member that fulfills this requirement. This facilitates the transformation of a complicated plane or space frame into a much simpler type of plane structure for analysis. From authors' summary

4497. Vol'vich, S. I., The strength of a girder-framework with a triangular grid (in Russian), *Trudi Saratovsk. Avtomob.-dor. In-ta*, no. 14, 140–147, 1956; *Ref. Zh. Mekh.* no. 11, 1957, Rev. 13332.

The solution is expounded of the problem on the strength of a framework of the beam type (with parallel belts and a rectangular lattice) in the elastic and the elastic-plastic zones subjected to the action of longitudinally applied compressive external forces. A deduction is given for finite differences equations for the longi-

tudinal deflection of the beam, and determinations are made for the critical values of the external forces. V. V. Povitskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4498. Vol'vich, S. I., Strength of a girder-framework with a double diagonally-strutted lattice (in Russian), *Trudi Saratovsk. Avtomb.-dor. In-ta* no. 14, 148–151, 1956; *Ref. Zh. Mekh.* no. 11, 1957, Rev. 13333.

An investigation is made of the strength of a double-diagonally-strutted framework of the beam type in the elastic and elastic plastic zones when under the action of longitudinal compression external forces. When deducing the finite differences equations for the longitudinal deflection of the framework an assumption is made regarding the retention of parallelity of the rods of the belts, possessing general obliqueness. It is established that this premise appears to be accurate for elastic deformations and approximate for plastic deformations. V. V. Povitskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4499. Rowe, R. S., Amplification of stress and displacement in guyed towers, *Proc. Amer. Soc. Civ. Engrs.* **84,** ST 6 (*J. Struct. Div.*), Pap. 1821, 20 pp., Oct. 1958.

This paper pertains to certain problems dealing with the amplification of stress and displacement in guyed towers when changes in geometry are included in the analysis. A simplified method for determining the slack stress in the guy and horizontal displacements due to wind load has also been developed and presented.

From author's summary

4500. Nylander, H., and Eriksson, E., Effects of wall deformations on floor slab loads and floor slab deformations in multi-storey houses (in Swedish), Instn. Byggnadsstat. Medd. no. 29, 57 pp., 1958.

4501. Pinadzhyan, V. V., Some questions on the boundary condition of the compressed members of steel constructions (in Russian), Avtorefer. Diss. Dokt. Tekhn. Nauk In-ta Stroit. Materialov i Sooruzh., Akad. Nauk ArmSSR, Erevan, 1956; *Ref. Zh. Mekh.* no. 11, 1957, Rev. 13168.

4502. Fertis, D. G., and Zobel, E. C., Equivalent systems for the deflection of variable stiffness members, *Proc. Amer. Soc. Civ. Engrs.* **84,** ST 6 (*J. Struct. Div.*), Pap. 1820, 13 pp., Oct. 1958.

A general method is presented for calculating the deflection of members with variable stiffness to any desired degree of accuracy. The method is based on fundamental principles and concepts of engineering mechanics which are known to structural engineers. A member of variable stiffness, EI, loaded in some manner, may be replaced by selected members of uniform stiffnesses, which will have the identical deflection curve of the original member. The loading of these members is changed, but the boundary conditions and length are kept the same. The equivalent systems of uniform stiffness are derived and proved mathematically. To facilitate the mathematical computations, an accurate approximation is suggested by the authors which yields results to any desired degree of accuracy.

This method may be applied to any statically determinate or indeterminate problem which deals with members of variable stiffnesses. From authors' summary

4503. Lebedev, V. A., Calculations for rod-formed domes on rigid joints with symmetrical loading of the joints, taking into account the deformation due to bending (in Russian), *Nauch. Tr. Leningr. Inzh.-Stroit. In-ta* no. 23, 118–133, 1956; *Ref. Zh. Mekh.* no. 11, 1957, Rev. 13323.

A method is proposed for the calculations of rod-formed domes on symmetrically loaded joints with consideration for the joint rigidity. By virtue of the force of symmetry of construction and of loading, the problem merges with the calculation of one of the ribs as a beam on elastic supports. The role of the elastic supports completes the ring of the dome. The deformation of the joints leads to the horizontally linear V and the angular transpositions v, in functions of which the ring reactions are determined: the reactive forces R and the reactive moments G. The calculation takes into consideration the diagonal deflection of the ring rods. To find the unknown the method of forces is used or a mixed method (when there are hinged joints between the ribs and the base of the dome). When there is a rigid bond of ribs with the dome base the number of canonical equations is equal to the doubled number of rings; when there is a hinged joint of the ribs with the dome base the number of equations increases by one.

I. G. Popov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4504. Selbo, M. L., and Knauss, A. C., Glued laminated wood construction in Europe, *Proc. Amer. Soc. Civ. Engrs.* **84,** ST 7 (*J. Struct. Div.*), Pap. 1840, 19 pp., Nov. 1958.

The status of European glued-laminated wood construction prior to 1956 is described. Since that time, the use of such glued structures has increased considerably with the establishment of licencees for (1) the described glued-up lattice-type I-girder system, (2) the described I-girder systems with (a) webs consisting of glued laminations with the grain of adjoining laminations at 15° angles and (b) nail-glued flanges nailed to the web, (3) the more recently introduced I-girder system with a wavy beech-plywood web glued into flange grooves. While more than 40 German producers of the second-mentioned, Swiss-invented, I-girder system have been approved prior to 1959, only a few companies are manufacturing the I-girder described under Item 1, and only three German companies have been set up to mass-produce the Wellenstegtraeger, Item 3.

The emphasis in Europe is on light, glued, nail-glued, and nailed construction, to save lumber at the expense of increased cost of the required labor, since wood construction can, in certain European countries, be even more expensive than construction with steel under prevailing economic conditions.

E. G. Stern, USA

Structures: Composite

(See also Revs. 4275, 4452, 4462, 4476, 4532)

4505. Trojanovic, M., Concrete bridges, Parts I and II (in Croation-Serbian), *Naše Gradevinarstvo* **12,** 3, 49–54, Mar. 1958; **12,** 4, 79–84, Apr. 1958.

Part I discusses fundamental problems of massive bridges in general, their basic functions and characteristics, history and successive progress and developments from olden times up to today. Seven important periods are specifically described: pre-Roman, Roman, middle age, renaissance, 18th and 19th century, 1900–1930, and from 1930 to today, referring to bridges in bricks, stone, plain concrete, and reinforced and prestressed concrete. Ideas and opinions of leading bridge engineers and architects are cited, as J. Burroughs, K. Pearson, R. L'Hermite, Ivo Andrić, V. M. Medaković, H. Troyat, J. Pilpoul, J. R. Perronet, P. Sejourne, H. Lossier, E. Arnaud, Caquot, C. Dobell, R. Maillart, E. Freyssinet. History of bridges goes back 5000 years, and some bridges of greater interest are mentioned with their characteristic features.

Part II deals with principles of conception, design and construction of bridges from the following standpoints, treated sep-

arately: (1) Objectivity; (2) Functionalism; (3) Stability and safety; (4) Rationality and solidity; (5) Inventiveness and originality; (6) Aesthetics. Author again refers to the opinion and criticism of recognized experts, most of them already mentioned in Part I, with added ideas of R. Vallette, A. Mesnager, Godart, Ch. Rabut, Tourtay, Koenen, E. Flammarion and others.

Author concludes his articles with recommendations for further progress in design and construction of bridges, namely: (1) Education of young engineers should include also knowledge in the fields of general culture, arts and aesthetics. (2) Thorough study and consideration of pertaining regulations and building codes. Builders with proper education, knowledge and experience should have the freedom to apply their own ideas in the construction, naturally under approval and supervision of the designers. (3) Better understanding of basic principles by all individuals involved. (4) Necessity and importance of the unity and the synthesis should never be overlooked.

J. J. Polivka, USA

4506. Lund, C. V., Timber bridges on the railways, *Proc. Amer. Soc. Civ. Engrs.* **85,** ST 1 (*J. Struct. Div.*), Pap. 1912, 77–86, Jan. 1959.

Advantages and limitations of railway timber bridges, trestles, and culverts are discussed. Variations in specifications are described. A resume of current research in this field with a view to improved design and service life is presented. Fire-retardant treatment and fire-control measures are emphasized. Glued laminated construction may be the answer to some of the problems with which the railroads are confronted. "Railroads will be building bridges of timber far into the future."

E. G. Stem, USA

4507. Looney, C. T. G., High-speed computer applied to bridge impact, *Proc. Amer. Soc. Civ. Engrs.* **84,** ST 5 (*J. Struct. Div.*), Part I, Pap. 1759, 41 pp., Sept. 1958.

The analysis and results of a study of the impact on highway bridges is described. The analysis was made on the IBM 704 high-speed digital computer. The programming of this analysis was done by means of Fortran, an automatic coding system written in language closely resembling ordinary mathematical language and specially designed for engineering work. The effects of different bridge and truck characteristics are presented, and a dimensionless representation of all the variables.

From author's summary

4508. Niwa, Y., and Mori, C., Studies on the earthquake resistant properties of earth and rock-fill dams (in Japanese), *Trans. Japan Soc. Civ. Engrs.* no. 58, 86–94, Sept. 1958.

In order to construct a large earth and rock-fill dam in Japan where great earthquakes frequently occur, it is necessary that the behavior of the dam suffering from earthquake shock be investigated in detail. For this purpose, experimental studies on the earthquake-resistant properties of three types of dam sections based on individual designing conditions were performed with a shaking table of impact type. That is, displacement and acceleration in the dam bodies, as well as change of dam sections, when the dams suffered from earthquake shock, were measured, and the earthquake-resistant characteristics of the dams are discussed from the results. From authors' summary

Courtesy, Editorial Committee of the Japan Society of Civil Engineers

4509. Mantle, K. G., Marshall, N., and Palmer, P. J., Experimental investigation into the stress distribution in a band-reinforced vessel, Instn. Mech. Engrs., Prepr., 13 pp., 1958.

Authors pressure-tested a 5-ft diameter by 9-ft long cylindrical vessel with hemispherical heads. Cylindrical portion is of same thickness as heads but is reinforced with 3-in. wide circumferential bands built up as 13 layers of ¼-in. thick strip. Tests correlate closely with theory and indicate that bands were 60% effective at design pressure and essentially 100% effective at the maximum pressure, with failure occurring in some of the bands. Analytical and experimental procedures were routine. Authors conclude that tests indicate acceptability of 50-ft diameter nuclear reactor vessel. W. E. Cooper, USA

Book—4510. Bonded aircraft structures (Papers from Conference arranged by Aero Research Ltd., at Duxford, Cambridge, in 1957), Duxford, England, CIBA (A. R. L., Ltd.), 1958, vii + 177 pp.

Although this book is primarily devoted to the techniques of bonding and inspecting bonded aircraft components, it contains much material of more general interest on the strength of bonds, geometry-strength relationships, and engineering-design aspects of bonded structures.

A brief but good exposition of some fundamental aspects of adhesion is provided by H. A. de Bruyne. This is followed by sections on design aspects, various methods of bonding utilizing presses and fluid pressure, tools for bonding, honeycomb structures, and inspection.

Much of the discussion of bonding is devoted to the use of "Redun" and "Araldite" proprietary adhesives. This restricts the applicability of the book. Nevertheless, there is much excellent material in it for the engineer interested in the subject of bonded aircraft components. A. G. H. Dietz, USA

4511. Benthem, J. P., and van de Vooren, J., Analysis of panels with bonded, hat-shaped stiffeners, loaded in shear, *Nat. LuchtLab. Amsterdam TN* S. 520, 18 pp., Feb. 1958.

A solution is given for the distribution of shear flow in panels with bonded, hat-shaped stiffeners loaded in shear, in order to obtain equations for the effective panel thickness and the maximum shear stress in the glue layer. The results of this analysis are simplified to make them manageable in practice.

From authors' summary

4512. Hoppe, R. R., The role of dynamic techniques in the design and development of high speed aircraft (in English), C. R. Journées Internationales de Sciences Aéronautiques, Paris, May 27–29, 1957; Part I, 1–25. O.N.E.R.A.

Machine Elements and Machine Design

(See also Rev. 4375)

Book—4513. Englisch, C., Piston rings. Volume II. Operation and testing [Kolbenringe. Band II. Betriebsverhalten und Prufung], Vienna, Springer-Verlag, 1958, vi + 331 pp. $14.75.

This is the second of a two-volume work on the subject of piston rings. Together they make up a detailed and exhaustive study of the subject. Volume I covers the theory of piston rings and their manufacture. The present volume is concerned with piston ring practice. In the opening chapter the author deals with the ring requirements of various types of machines, i.e., number of rings and ring configuration. Ring and groove geometry and selection of ring materials are discussed. Subsequent chapters cover thermal stresses, wear, lubrication and such specific problems as seizing and breaking of rings. Brief sections are devoted to proper assembly and disassembly, and to testing and inspection. An appendix contains microphotographs showing structure development (with reference to graphite formation, grain size, etc.) for a wide selection of piston-ring materials. This book is painstakingly

prepared with many photographs and diagrams and should be extremely useful to a specialist in the field.

A. G. Sharp, USA

4514. Lauria, E. H., Synthesis of the criteria of dimensional rational design of machine elements, Parts I and II (in Portuguese), *Cienc. y Tecn.* **125,** 629, 205–226, June 1958; **125,** 630, 276–295, July 1958.

The different rational criteria are systematized, with didactical intention, which may serve as a basis to the design of machine members. It is quite obvious that, according to the nature of the piece and the conditions of its working, the calculation of its fundamental dimensions must be accomplished with regard for different mechanical and physical requirements. Out of the six criteria which are pointed out (strength, stiffness, lubrication, heating, mechanical vibrations and "life") some began with the rational study of applied mechanics, while others are more recent and owe their importance to the increasing speed of machinery and to the severe work conditions that machine members have to bear.

From author's summary

4515. Orbeck, F., A study of shrink-fitted assemblies loaded in torsion with special reference to damping capacity, Instn. Mech. Engrs., Prepr., 13 pp., 1958.

Author's theoretical model consists of a shaft to which torque is applied at its free end, well away from the nearest end of the shrink-fitted and thick-walled cylindrical hub. When torque is applied, local slip may occur at the mating surfaces, that is, near the latter end, and when the local shearing stresses tend to exceed the friction grip. Farther away the hub and the shaft will behave as an integral part.

Assuming the elastic limit nowhere to be exceeded, and by means of a relaxation technique, the extent of the slip zone has been determined as a function of the ratio between the nominal shearing stress in the free end of the shaft and the friction grip available. Finally, from the circumferential amplitude of the slip under a fluctuating torque, the energy dissipation caused by friction damping has been assessed.

The theoretical results so obtained have, on the whole, been corroborated by experiments on a two-mass vibrational system consisting of a shaft, on either free end of which a hub had been shrink-fitted.

H. Blok, Holland

4516. Mangeron, D., and Dragan, C., Application of a new tensor method to the kinematic study of the spatial slider-crank mechanism (in Roumanian), *Bul. Inst. Politehn Iasi* **12,** 1/2, 327–338, 1958.

After reviewing existing methods used for investigating spatial mechanisms, authors present a new tensor method characterized by a position orthogonal tensor of the second order and by a corresponding velocity tensor for the relative motion of a link with respect to the preceding one in a kinematic chain. By applying this method to the spacial slider-crank mechanism and to its plane particularization, authors present the problem of configurations with its necessary fictitious transformations, express the tensor components function of Lagrange's parameters of the kinematic pairs and construct the tensor equations which lead to solving the proposed problem.

Method proved to the useful and easy to apply.

Cr. Pelecudi, Roumania

4517. Schmidt, E. H., Cycloidal-crank mechanisms, *Mach. Design* **31,** 7, 111–114, Apr. 1959.

Paper discusses how to get intermittent or irregular motion with various forms of crank mechanisms that generate cycloidal, epicycloidal or hypocycloidal displacements.

From author's summary

4518. Hunt, K. H., Exact linear simple harmonic motion by a space-linkage, *Austral. J. Appl. Sci.* **9,** 4, 332–336, Dec. 1958.

Paper generalizes an earlier result of A. A. Sherwood [*Austral. J. Appl. Sci.* **9,** 96–104, 1958].

Proportions are derived for a class of spatial slider-crank mechanisms in which the output translation is exactly proportional to the sine of the input angle of rotation. The mechanism consists of an input crank, a connecting rod having ball joints at both ends, and an output link sliding along an axis which intersects the crank axis. While this type of mechanism is well known and has been analyzed graphically before [e.g., "Space mechanisms" by R. Beyer, Trans. Fifth Conference of "Mechanisms," Purdue Univ., Lafayette, Indiana, Oct. 1958, pp. 141–163], the algebraic analysis and results of Hunt are new, and therefore of interest, as far as is known to this reviewer.

F. Freudenstein, USA

4519. Toftdahl Olesen, H., Calculations on jog conveyor (in English), *Acta Polytech. Scandinavica* no. 220, 36 pp., (Mechanical Engineering Series Vol. 3, no. 11), 1957.

By analysis of the movement of transport goods in an oscillating trough, several typical movement patterns were found. Each of these is characterized by its special combination of the elements: sticking fast, gliding forwards, gliding backwards and hopping.

Based on inertia equations derived for separate movement types, the transport capacity of a jog conveyor with arbitrarily fixed frequency, length of stroke, direction of stroke and friction coefficient were calculated. The results are compared in practical experiments.

Finally, author attempts to find optimal values of the above data to determine the best design for a jog conveyor of a desired capacity.

From author's summary

4520. Thomson, J. L., Packed glands for high pressures: an analysis of fundamentals, *Combustion* **29,** 11, 38–51, May 1958.

Fastening and Joining Methods

4521. Gloss, R. H., Timber fastenings, *Proc. Amer. Soc. Civ. Engrs.* **85,** ST 1 (*J. Struct. Div.*), Pap. 1913, 15 pp., Jan. 1959.

Timber fastenings are discussed by a person connected with manufacturing of split-ring connectors, shear plates, and Trip-L-Grip anchors. Their advantages and limitations are well described on the basis of the vast experiences of the author in this field.

In other fields, however, the author's experiences may be somewhat limited. Thus, ". . . . . adhesives will undoubtedly replace many mechanical connections . . . . ." in the field of wood construction. The limitations of the use of adhesives are so stringent that they may be considered outside of the realm of nonlaminated wood construction (in contrast to wood assembly) in the U. S. A. Specifically, the extraordinary rigidity of glued structural joints limits the use of glue in nonlaminated structures because of the size of the secondary stresses resulting from such joint rigidity. In contrast, most mechanical joints allow movements and adjustments, thus reduce secondary stresses to a safe minimum without causing excessive joint deformations.

Subject to discussion may also be the statement that ". . . . . the common wire nail . . . . . has remained virtually unchanged for a half-century or more, not because improved nails were not available but because the ordinary nail was satisfactory and there has been no economic or market pressure for a better nail." Quite to the contrary, the demand for improved nails by the public, including whole industries, has been so outstanding that today these industries demand the use of improved nails and reject the application of their products with common wire nails. Thus, for instance, most of the wood strip flooring is to be fastened with helically threaded nails; all asbestos siding is fastened with

threaded nails of one type or another; almost all U. S.-made pallets are assembled with threaded nails, in replacement of common wire nails, fluted nails, and wood screws as are still used at this time in some of the European countries where threaded nails of the high U. S. standard are not available. Entirely new wood assemblies have been made possible as a result of the availability of these improved threaded nails [see "Better utilization of wood through assembly with improved fasteners," V. P. I. Wood Research Laboratory Bull. no. 38]. These assemblies include nailed trussed rafters, so popular in this country, and omitted from consideration by the author.

Another statement reads that ". . . . . in the case of both nails and bolts . . . . . merely a change in metal would prove a stronger fastenings . . . . . but there has not been sufficient demand to bring about a change." This is correct sofar as the low-carbon-steel common wire nail is concerned, which will always be made of soft steel, being the common nail. On the other hand, the demand for stronger and stiffer nails has been such that high-carbon-steel nails and, especially, hardened high-carbon-steel nails are standard items of manufacture today. They have been used for the assembly of wood structures and, particularly, of nailed trussed rafters which were designed for the use of these improved helically threaded nails. In the case of U. S.-made hardwood pallets, almost all are assembled with bright or hardened high-carbon-steel nails, just to mention one industrial product completely relying on their use. Similarly, aluminum, bronze, brass, stainless steel, Monel, and other metal-alloy nails have been in mass-production and are used to great advantage as fastenings for wood.

In connection with the statement " . . . . . no change (in connectors) has occurred in Europe," reference is made to the Rox timber connector introduced successfully in the Scandinavian countries by Professor Andersen of Norway's Polytechnic Institute (following review).

"It is also ironic that less detailed design and test data are available on nails . . . . . than on the much newer timber connectors." This statement is correct if basic information gathered in Europe is not given consideration by U. S. engineers. True, nailed construction, such as nailed framing, has been taken for granted and given little consideration in U. S. research laboratories, while in Europe, such as in Karlsruhe, the reputation of a laboratory may be based on their research on nailed structures and assemblies.

E. G. Stern, USA

4522. Andersen, A., Study of double-toothed Rox timber connectors (in Norwegian), Institute of Steel and Wood Construction of Technical College of Norway, Rep. 1, 41 pp., 1958.

As many as 120 tests were performed on timber joints of Norwegian spruce and pine, assembled with $\frac{5}{8}$-in., $\frac{3}{4}$-in., and $\frac{7}{8}$-in., steel bolts and 3-in.-diam, double-toothed, Rox timber connectors with 48 cone-shaped steel teeth placed on each side of the steel plate. The distance from point to opposite point of the teeth is $\frac{3}{4}$-in., allowing a penetration of almost $\frac{3}{8}$-in. into the wood. The pressure required to force the teeth into wood averaged 5500 lb. To determine the load transmission only by the connector, some tests were performed on joints with the bolts inserted into slotted holes. The influences of moisture content, angle of grain, spacing, and edge distance were determined. Design loads per connector were advanced on the basis of a factor of 2.5 giving consideration to variations in strength and moisture content of the lumber, to the time effect, and to variables in fabrication.

E. G. Stern, USA

4523. Shimonskii, Yu. A., Investigation of the strength of a riveted joint stressed in tension (in Russian), Collection of Papers on Ship-Building, Leningrad, Sudpromgiz, 1954, 41-48; *Ref. Zh. Mekh.* no. 10, 1957, Rev. 12205.

For the investigation of the distribution of stresses in a riveted seam the discretely distributed rivets are replaced by a continuous seam of a width $t = s/e$, where s is the area of the section of the riveted part, e is the distance between the rivets. The change of position of the first sheet the author determines by the incorrect formula

$$\Delta_1 x = \frac{1}{EF_1}\int_0^x\int_0^x f(x)\,dx^2$$

The correct formula for the transposition of the first sheet would be

$$\Delta_1 x = \frac{1}{EF_1}\int_0^x \left(P - \int_0^x f(x)\,dx\right) dx$$

In consequence of this mistake, which recurs repeatedly in the determination of the constants entering into solution of the differential equation, author arrives at the equation [10]

$$f(x) = \frac{Pa}{\text{sh al}}\,\text{ch ax},\quad a^2 = \frac{kt}{E}\,\frac{F_1 - F_2}{F_1 F_2}$$

instead of the correct result

$$f(x) = \frac{Pa}{(F_1 + F_2)\,\text{sh al}}\,[F_1\,\text{ch ax} + F_2\,\text{ch}\,a(l - x)]$$

$$a^2 = \frac{kt}{E}\,\frac{F_1 + F_2}{F_1 F_2}$$

Utilizing the incorrect expression, author reaches the wrong conclusion regarding the even distribution of forces in the riveted seams, when the areas of the seams are the same, which is in disagreement with all experimental and theoretical investigations on record. The correct solution of the problem in the form being investigated has long been known. It can be found, for instance, in the book by G. A. Nikolaev and A. S. Gel'man ["Welded constructions and joints," Moscow, 1937, (and 1947)]. The article was first published in 1931.

A. V. Dyatlov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4524. Kedrov, A. I., Influence of some technological defects in the preparation of welded joints on their vibration strength (in Russian), *Trudī Vses. N.-i. In-ta Transp. Str-va* no. 20, 163-202, 1956; *Ref. Zh. Mekh.* no. 11, 1957, Rev. 13500.

With the object of determining the maximum limit of divergence from the normal of the seam quality, determinations were made to establish the influence of defects in seam joints on their strength. Components of welded structures were tested, the material being steel of low carbon content 10 and 24 mm thick, with butt-welding seams under different qualities of performance when subjected to varying loading. Most attention was devoted to the study of the influence on fatigue strength of welded seams of external and internal pores and also of slag inclusions. It was shown that the fatigue endurance of butt-welded seams does not depend on the size of single or group separately disposed pores but does depend to a large extent on the porosity, accompanied by blisters and inclusions. The presence of pores in the bonding seams may also cause a lowering of their fatigue endurance. In evaluations account must be taken not only of the depth of the defects, but also of their situation in the seams. Samples with insignificant technological defects may show a fatigue endurance somewhat higher, by comparison with the untreated butt seams and other forms of joining with constructional concentration of stresses.

G. A. Nikolaev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4525. Gotovskii, K. M., Deformation of thin sheet metal when being cut by gas (in Russian), *Trudī Tsentr. N.-i. In-ta. Recb. Flota* no. 28, 93-117, 1954; *Ref. Zh. Mekh.* no. 3, 1958, Rev. 3259.

The problem is solved with consideration for the irregular distribution of the temperature on the strip's section during the boundary thermal state, and on the acceptance of the hypothesis of the conservation of plane sections. The temperature field is determined as the result of the summing up, for each point, of the thermal effects created by the linearly concentrated sources of heat (in consequence of the burning of the metal in the oxygen) and the normal curvature due to the action of the flame on the surface of the metal. The curvature of the plate is found from the condition of the distribution of T in the section, passing through the ordinate y_{max} of the isotherm 600°. The values of the residual deformations are found, while taking into account the plastic deformations formed during heating; formulas are given for the determination of the residual radii of curvatures in dependence on the correlation of the width of the cut plate to the width of the zone of plastic deformation, and nomograms are produced, linking the length, width of the strip and value of its residual deflections. An investigation is made of the residual deformations of the deflection of the strips when cutting them along one and along two edges of the rational sequence of the cutting of several strips from one sheet, and of the limitations of possible application of the cutting of components without allowances.

G. A. Nikolaev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Rheology

(See also Revs. 4589, 4785, 4786)

4526. Adkins, J. E., Dynamic properties of resilient materials: constitutive equations, *Phil. Trans. Roy. Soc. Lond. (A)* **250**, 985, 519–541, July 1958.

Constitutive equations are formulated for a class of resilient materials for which the stress depends both upon the deformation and upon the time rates of variation of the tensors defining it. Particular attention is given to aeolotropic bodies, the stress deformation relations for orthotropic and transversely isotropic materials being put in forms which exhibit symmetry properties of the material. In the discussion of symmetry properties, attention is confined to the case where the stress tensor is a polynomial function of two only of the kinematic tensors. Convected coordinate systems are employed in the development of the theory, but the method of transformation of the equations to a fixed frame of reference is also given.

From author's summary by L. E. Malvern, USA

4527. Sinitsyn, V. V., Viscous properties of plastic dispersion systems and the effect of adjacent slip (in Russian), Trans. All-Soviet Conference on Colloid. Chem., 1953, Moscow, Akad. Nauk SSSR, 1956, 127–143; *Ref. Zh. Mekh.* no. 3, 1958, Rev. 3093.

A viscosimeter of the capillary type is described for the study of the effect of adjacent slip (P-effect) on consistent (bodied) lubricants. In the investigations glass and copper capillaries of various diameters were used (from 0.1 to 0.6 mm), and of various lengths (6.8 to 80 cm). The P-effect was studied when using fatty constalin, fatty lubricant grease (calcium soap grease), lubricants GSA and GOI-54. Curves are given to show the relations of the effective gradient of velocity D_{eff}, calculated on the volume of lubricant passing through the capillary, to the shear stress τ. The curves disclose the relation of the value D_{eff} to the radius of the capillary R, conditioned by the next-to-the-wall slip. The equation of this relation has the form

$$D_{eff} = D_{vol} + \frac{k(\tau - \tau_0)}{R}$$

where D_{vol} is the mean gradient of velocity in the space, τ_0 is the limit of solidity of the layer next to the wall, R is a constant characterizing the three-dimensional rheological properties of the lubricants mentioned, at various temperatures. It was established that the anomaly presented by the viscosity of the three-dimensional layers is indicated in a significantly more powerful manner than of the next-to-the-wall layer. A comparison of the viscous-temperature characteristics of the spatial and adjacent-to-the-wall layers showed that value R falls with the increase of temperature markedly faster than the viscosity in the space. It is noted that homogenization of some consistent lubricants significantly decreases the P-effect.

N. I. Malinin

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4528. Koganovskii, A. M., and Petrenko, V. G., Behavior of a two-phase suspended layer (in Russian), *Kolloid. Zh.* **16**, 3, 184–190, 1954; *Ref. Zh. Mekh.* no. 10, 1957, Rev. 11772.

A suspended layer consisting of a mixture of two dispersed components, the particles of which interact because of cohesion, is subjected to examination. The first group of experiments were carried out on a homogeneous suspended layer consisting of flakes of the hydroxides of aluminum and iron and powdered activated charcoal and chalk. The results agree well with the formula of N. I. Smirnov and Li De-ep [*Zh. Prikl. Khimii* **24**, 56, p. 383, p. 438, 1951]; some increase in the form factor (the ratio of the sphere's surface to the particle surface of equal volume) at small flow velocities is explained by the authors as due to the random aggregation of the particles. The second group of experiments centered on the two-component suspended layer consisting of a mixture of granules of aluminum hydroxide and powdered activated charcoal and chalk and mixtures of flakes of iron hydroxide with powdered activated coal. It was shown that the degree of widening of the suspended layer and the form factor of the secondary particles, resulting from the aggregation, retain an almost constant value within wide limits of changes of the composition of the mixture; however, this constant value of the form factor differs sharply from the value of the form factor in the corresponding homogeneous suspended layers.

G. I. Barenblatt

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Hydraulics

(See also Revs. 4285, 4286, 4325, 4644, 4648, 4651, 4658, 4664, 4786, 4798, 4799, 4800)

Book—4529. Bella, Š., and Bella, V., Struggle against water and for water [Boj s vodou a o vodu], Bratislava, Slovenské Vydavatel'stvo Technickej Literatúry, 1956, 312 pp. 28.30 Kčs.

Popular treatise on hydraulic engineering, prepared by a noted Slovak professor, Š. Bella (1880–1952), is edited by his son. After an historical review a concept of hydraulics is presented, followed by chapters give engineering hydrology, hydrography and hydrometry. Struggle against water means flood protection, river regulation, drainage. Struggle for water covers waterways, water supply, irrigation. Hydraulic structures and machinery conclude this encyclopedic and neatly illustrated book, an introduction to a textbook.

S. Kolupaila, USA

Book—4530. Dub, O., General hydrology of Slovakia [Všeobecna hydrolo'gia Slovenska], Bratislava, Vydavatel'stvo Slovenskej Akadémie Vied, 1954, 151 pp. Kčs. 40.

Interesting hydrologic sketch of the territory of Slovakia, which belongs mostly to the basin of the Danube, with only a small part to the Vistula. Detailed list of basin areas is given to 0.001 square kilometer. Slovakia has 367 gaging stations, some of them established in 1823, 725 rain gages and 29 evaporation pans.

Ground water fluctuations are observed in 311 stations. Runoff for several rivers was computed with sufficient accuracy for 50 years (1901–1950). Author used the basic data of high quality for many important conclusions. 26 illustrations of rivers in Slovakia conclude this book which presents much useful information about this part of Europe. S. Kolupaila, USA

4531. Szigyarto, Z., Mathematical methods in hydrological investigations (in Hungarian), *Hidrológiai Közlöny* **37**, 3, 226–230, 1957.

4532. Obrazovskii, A. A., Reinforcement of the leakage of streams behind the buttresses of a dam with the help of a broken spillway wall (in Russian), *Trudi Gidravl. Labor. Vses. N.-i. In-ta Vodosuab. Kanaliz., Gidrotekhn. Sooruzh. i Inzh. Gidrogeol.* no. 5, 50–57, 1957; *Ref. Zh. Mekh.*, no. 3, 1958, Rev. 2905.

When positioning the GES units in the buttresses of a low head dam their width was designed for 12 m, and the width of the spans at 22 m. The design for the combination of the assembly was checked on a scale of 1 : 100 on the river-bed model and on a scale of 1 : 50 in a trough. The experimental investigations showed that when passing through flood waters, when the electric station is not working, eddy zones are formed behind the buttresses with counter currents, which cause an uneven passage of the water discharge to the "lower water" and local scouring. In order to secure a sufficiently even distribution of the specific discharges of the flow at the outlet from the apron a form of spillway wall with a broken surface in plane was adopted. V. V. Fandeev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4533. Topchibashev, N. K., Problem of calculations for an open lateral water-intake (in Russian), *Trudi Energ. In-ta Akad. Nauk AzerbSSR* **11**, 99–114, 1953; *Ref. Zh. Mekh.* no. 3, 1958, Rev. 2903.

Article consists of (1) briefly stated information on existing methods of hydraulic calculations of a submerged spillway with a wide threshold, (2) a description of a field investigation of one of the water-intakes, (3) a comparison of the actual inputs of this water-intake with the inputs calculated by means of the several available methods. It should be noted that the hydraulic calculation of open water-intakes of hydroelectric stations is proposed to be effected by methods worked out for a spillway with a wide front, and that these methods do not sufficiently take into account the fully active conditions of the work of the water-intakes, in particular, the direction of the flow in the underwater stream. The field observations, having as their objects the study of the form of the free surface of the flow, of the velocity field and the determination of the input, were carried out at the water-intake of one of the hydroelectric installations of the Azerbaidzhausk SSR. From the comparison of the inputs it follows that the calculation methods used in the paper furnish exaggerated values. However, it is essential to make note of the fact that the measured falls in level covered by the calculation formulas only amounted in all to 3–8 cm.

The paper is carelessly written; there are many misprints; and some of the author's ideas are not clearly expressed. The water-intake is described in an extremely schematic fashion; information is lacking about its form; not a single dimension is given, no data is furnished for the regime of the water-current at the inlet to the container placed in front of the water intake.

D. I. Kumin

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4534. Karev, G. A., The inclusion of syphon spillways in a project (in Russian), *Sb. Nauch. Trudi Tomskogo Inzh.-Stroit. In-ta* **2**, 97–123, 1957; *Ref. Zh. Mekh.* no. 3, 1958, Rev. 2908.

Author gives a detailed analysis of the process of the inclusion of a syphon spillway in the project, dividing the full, as well as the partial, inclusion into three forms: (1) Continuous without suction of air; (2) continuous with suction of air; (3) discontinuous, or arranged in stages, with periods of suction of air. The basic factors determining the process of inclusion are taken to be: (1) The sensitivity of a syphon spillway for inclusion in the project (by this the author understands the capacity of the syphon "to guarantee a certain degree of approximation of the discharge effected by it in the process of inclusion to the natural magnitude of the inflow discharge" in the "upper water."); (2) the initial discharge of the inflow and the intensity of its increase in the "upper water" in the process of inclusion; (3) the character of the change of the accumulating capacity of the "upper water" higher than the level, corresponding to the level at the beginning of the inclusion of the syphon in the project. V. V. Fandeev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4535. Melin-Nubarov, S. G., Hydraulic calculation for a bottom grid (in Russian), *Gidrotekh. Stroit.* no. 11, 37–39, 1956; *Ref. Zh. Mekh.*, no. 3, 1958, Rev. 2907.

The case is investigated of the complete absorption of the given input through a bottom grid, at a level of water in the water-intake gallery which is lower than the lower surface of the grid. Author shows that the input of the bottom grid coefficient does not depend on its angle of inclination, while the decrease of the collected input when the angle of inclination of the grid is increased is explained by the inertia of the passage of flow along the grid. To avoid this passage and in order to make full use of the width of the grid a recommendation is made to construct in front of the grid a cross-over section, the length of which would be determined by the proposed formula. V. V. Fandeev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4536. Gunko, F. G., Forms of conjugation of pounds in three-dimensional conditions with a bottom flow condition on a smooth sill (in Russian), *Izv. Vses. N.-i. In-ta Gidrotekhn.* **55**, 133–155, 1956; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 6690.

Book—4537. Richter, H., Handbook of pipe hydraulics [Rohrhydraulik ein Handbuch zur praktischen Stromungsberechung], 3rd ed., Berlin, Springer Verlag, 1958, xii + 354 pp. DM 37.50.

Book is well known to hydraulic engineers familiar with German language and technique. The third edition is moderately revised in text compared with the second edition. Some new references are inserted and hydraulic coefficients and physical constants are revised. Use of formulas and coefficients is illustrated by many examples. Owing to comprehensive representation of theory and experiments, physical constants, diagrams and coefficients for practical calculations, book might be useful to all engineers interested in flow of gases and fluids.

H. T. Kristensen, Sweden

4538. Chernikin, V. I., Hydraulic resistance of welded tube conduits (in Russian), *Trudi Akad. Neft. Prom-sti* no. 3, 246–249, 1956; *Ref. Zh. Mekh.* no. 3, 1958, Rev. 2889.

During the gas or electro processes of welding of steel pipes a so-called "reinforcement" of the seams is formed at the butt-weld places, which increases the general hydraulic resistance of the tube conduits. The resistance of "reinforcements" of different outline was not investigated. The author is of the opinion that in the first approximation such butt-welds should be evaluated by the resistance of equivalent butts welded on ringed strips below a layer of flux. The butts of welded tubes are examined as axially symmetrical, acutely angled diaphragms with very large openings.

Author proposes to take account of the increase of hydraulic resistance of welded tube conduits on account of the "reinforcement" of the seams in the butt welds by means of the coefficient of local resistance by a butt λ_c according to the formula $\lambda_c = \frac{D}{l}\left[\frac{1}{\varepsilon\left(1-\frac{4e}{D}\right)}-1\right]^2$. Here D is the internal diameter of the pipe, d the diameter of the inlet section at the point where the butt-welds are situated, ε the compression coefficient of the flow, l the mean length of one pipe, e the height of the "reinforcement," equal to 0.5 $(D-d)$. For pipes with diameters of 200–400 mm the values of λ_c, calculated by the given formula, are equal to 0.0045 ÷ 0.0034. For the purpose of decreasing the values of λ_c the author puts forward a series of practical suggestions.

V. I. Gotovtsev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4539. Egorov, A. I., Calculations for miscellaneous perforated systems of small resistance (in Russian), Investigations on water treatment, Moscow, Gos. Izd. Lit. po Stru-vu i Arkhitekture, 1956, 233–267; *Ref. Zh. Mekh.* no. 9, 1957, Rev. 10302.

An investigation is made for the determination of pressure losses in perforated tubes, immersed in water below the free surface level, with variable and increasing discharge along their length.

P. G. Kiselev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4540. Bosano, E., Operation of a network of water distribution with a constant level supply reservoir and a regulating reservoir (in French), *Ann. Ponts Chauss.* **127**, 6, 737–793, Nov./Dec. 1957.

The network under review comprises a constant-level supply main, noncross-connected distribution mains, of which the instantaneous outputs are proportional to the total distribution output q, and a regulating reservoir.

I. When q oscillates between two extreme values, the reservoir tends to operate by filling and outflow oscillating between two extreme values.

II. When q is periodic, operation of the reservoir tends to be periodic and to have the following characteristics:

1. The reservoir regularizes the pressures without substantially changing the average pressures. The average water level is approximately equal to the hydraulic gradient at its point of connection with the network, as determined for the average flow in the absence of a reservoir. The difference between the extreme levels is equal to the volume of regularized water stored and discharged by the reservoir during each period, divided by its cross section;
2. As the supply output is not constant, this volume is less than the "total regularized volume" which would correspond to a supply output equal to the mean distribution output, this volume varying to a great extent according to the particular service. In the examples cited, it represents from 6 to 28% of the volume distributed during the period (24 hours).
3. For the reservoir to operate properly, the water level must remain within its floor and overflow levels. To offset both uncertainty of calculations and increased consumption, it must be possible to regulate the mean level by varying the supply pressure.

From author's summary by L. J. Tison, Belgium

4541. Ovsepyan, V. M., The expression of hydraulic losses through an averaged velocity during irregular motion of a liquid in a rigid tube (in Russian), *Sb. Naucb. Trudi Erevansk. Politekhn. In-ta* no. 14, 119–124, 1957; *Ref. Zb. Mekb.*, no. 3, 1958, Rev. 2893.

Author shows that the hydraulic losses in a pipe during irregular motion are greater than during a steady flow. A concept is introduced of a velocity v, averaged with time, for a steady motion, for which the quantity of water discharged in a given period of time is equal to the quantity discharged in the same interval of time for an irregular motion, and of some parameter τ having the dimension of time, dependent on the velocity and the coefficient of resistance. For the calculation use is made of coefficient β, obtained by the author, which is dependent on time t and parameter τ, which, when $t \to \infty$, approaches unity. The expression for the losses in an irregular motion is obtained by the author in the form $h_w = \beta\zeta_c\frac{v^2}{2g}$. β for practical cases equals 1.9 to 2.0, that is, the losses exceed by approximately two times those during a steady motion.

S. Ya. Vartazarov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4542. Pavlushenko, I. S., and Polishchuk, E. R., New calculation graph for the determination of loss of pressure due to friction (in Russian), *Trudi Leningr. Tekbnol. In-ta Im. Lensoveta* **39**, 204–215, 1957; *Ref. Zb. Mekb.* no. 3, 1958, Rev. 2891.

Authors hold the view that the application of Euler's criterion E, instead of using the resistance coefficient λ, appears to be more convenient and opens up possibilities of carrying out broad generalizations. The basis for the calculation is the adoption of an equation, describing the flow-motion in the pipe, of the form $E = CR^m\Gamma_1\Gamma_2^n$. Here $E = \frac{\Delta p}{\rho w^2}$, $\Gamma_1 = \frac{L}{d}$, $\Gamma_2 = \frac{e_\varepsilon}{d}$. Γ_2 is the relative roughness. For practical calculations the generalized graph $E = f(R, \Gamma_2)$ is recommended; this is drawn up over a wide range of Reynolds numbers R. In the composition of this graph formulas by different authors were made use of for the determination of the coefficient of hydraulic resistance in pipes with smooth and rough walls in a turbulent state (Blazius, Nikuradze, Konakov, Filonenko, Murin, Shevelev, Colbrook and Altshuhl). In so doing it was assumed that when $\Gamma_1 = 1$ $E = \frac{1}{2}\lambda$. Making use of the generalized graph, authors give a comparative evaluation of the application of the many formulas for the determination of λ and a number of recommendations for their use.

V. I. Gotovtsev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4543. Satarov, G. V., Hydraulic computations for petroleum conduits (in Russian), *Neft. Kb-vo.* no. 6, 53–56, 1957; *Ref. Zb. Mekb.* no. 3, 1958, Rev. 2892.

Results are given of the investigations, carried out on experimental apparatus, for the coefficient of hydraulic resistance for some types of pipe bends, constrictions and also of stop-valves. The working liquid in the experiments was petroleum (crude oil). The values of the coefficient of hydraulic resistance of the tested fashioned parts and fixtures were expressed by formulas of the form $\zeta = \frac{a}{R}$, $\zeta = \frac{b}{R^n}$ in relation to the limits of changes of Reynolds number R. The tests showed that the coefficient of hydraulic resistance of the fashioned parts and fixtures experimented on, in the laminar and transit regions when working with petroleum products, was always larger than the corresponding coefficients obtained during the movement in them of water in conditions of a quadratic regime.

V. I. Gotovtsev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4544. Al'tshul', A. D., Basic principles of uniform flow of water through channels (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekb. Nauk* no. 5, 85–94, May 1956.

Author claims a new universal formula for Chezy coefficient C is derived by him, accounting the viscosity in whole section and slope influence on the resistance. For the derivation of velocity formula he used Prandtl's method with some modification. Formula for C was derived for a wide rectangular channel. For practical purposes he proposes to use a simplified design equation $C = 20 \log\left[\frac{R}{\varepsilon + 0.004(Ri)^{-0.5}}\right]$, where R is hydraulic radius in mm, ε linear roughness in mm ($\varepsilon = 0.143K$, K is avg. height of roughness spot in mm), i bottom slope. A special scale for ε was given by author for different types of channel material. For smooth and rough channels author gives simplified formulas neglecting ε or the other term in the denominator, which do not differ much from other known logarithmic formulas. Twenty three bibliographical references in Russian are given.

The mentioned formula was discussed by Agroskin and Mostkov in the same issue of magazine. They indicated some unjustified assumptions in obtaining as general equation a design equation which was obtained by a simple substitution of the depth by R and by the use of constant ratio of bottom velocity to friction velocity equal to 8.27, meanwhile this ratio depends on channel roughness. Head loss for intermediate flow is greater than for flow in rough channels which is illogical. The use of formula in the intermediate zone was unjustified. A special roughness scale is inconvenient.

Kalitzun [*Gidrotekhnicheskoie Stroitelstvo* p. 51, 1, 1959] states the comparison of experimental results obtained by E. Marchi and computed by Al'tshul's formula are in sufficient agreement in the intermediate zone between smooth and rough channels. Formulas by Agroskin, Pavlovsky, and Al'tshul give the same results for rough channels.

I. J. Moskvitinoff, USA

4545. Nikitin, I. K., A new instrument for measuring turbulent flow values in sediment-carrying channels (in Uzbeg.), *Izv. Akad. Nauk UzSSR* no. 7, 45-55, 1956; *Ref. Zh. Mekh.* no. 8, 1957, Rev. 9248.

A method is described for measuring the mean square values of the pulsational velocities in a plane perpendicular to the direction of the flow. A 10% solution of $CuSO_4$ is fed into the flow through a thin-walled pipe arranged in the direction of the velocity. At a certain distance from the outlet cross section of the pipe, and in a plane perpendicular to the axis of the flow, an iron measuring grid of thin rods is installed. By measuring the size of the black spot formed on the instrument grid during a specified time interval it is possible to estimate the magnitude of the pulsational components of the velocity in the cross-sectional plane of the flow.

A theoretical formula developed by the author is presented which equates the diameter of the spot to the value of the mean square of the pulsational velocity. Measurements with this new instrument have been made by the author in laboratory conditions, as well as in canals of the Kara-Kalpak ASSR and the Kirghiz SSR. Measurements were made both in sediment-free flows and in flows carrying sediments.

N. A. Mikhailova

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4546. Asaturyan, A. Sh., Edigarov, S. G., and Chernikin, V. I., Laminar motion of viscous petroleum products in rectangular warmed channels (in Russian), *Trudi Akad. Neft. Prom-sti.* no. 3, 254-259, 1956; *Ref. Zh. Mekh.* no. 3, 1958, Rev. 2966.

An investigation is carried out of a plane steady laminar even motion of a viscous liquid in an open channel with a heated bottom. The calculation is accomplished by means of the Navier-Stokes equation, separately for the warmed liquid flowing along the bottom of the channel and for the cold liquid moving along its upper part. On the boundary of the cold and the heated liquids there is a joining up of the velocities and friction stresses. An equation is obtained for the full input of the liquid. The investigation of the obtained equation is given as well as a numerical example.

E. M. Minskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4547. Shifrin, S. M., Calculation for horizontal channel settling tanks for a given effect of clarification of the sewage (in Russian), *Nauch. Trudi Leningrad Inzh.-Stroit. In-ta* no. 25, 14-27, 1957; *Ref. Zh. Mekh.* no. 3, 1958, Rev. 3071.

An approximate solution is given for the fall-out of the suspension in two portions in a horizontal channel settling tank: the basic and the initial, including the watergate zone. Curves are given, enabling rapid computations to be made for the parameters of a settling tank with depths of 1, 1.5 and 2 m for a set degree of clarification of the flow or vice versa. An example of the calculations is furnished.

O. L. Yushmanov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4548. Einstein, H. A., and Li, H., Secondary currents in straight channels, *Trans. Amer. Geophys. Un.* **39**, 6, 1085-1088, Dec. 1958.

A condition is derived from the basic flow equations for the growth of vorticity in a parallel flow along a straight channel. No terms containing average velocity components are involved, indicating that secondary flows do not develop spontaneously in laminar flows. In turbulent flows the condition will be fulfilled near a boundary when the isovels are not parallel to the boundary or to themselves.

G. H. Lean, England

4549. Astrakhantsev, V. I., Problems of calculation of erodable canal beds (in Russian), *Trudi Aralo-Kaspiisk Kompleksnoi Ekspeditsii Akad. Nauk SSSR* no. 7, 70-78, 1956; *Ref. Zh. Mekh.* no. 11, 1957, Rev. 12703.

Questions are discussed of the stability characteristics of the canal bed, the classification of the sediment and different proposals for determining the transporting capacity of the flow.

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4550. Levitskii, B. F., Application of the principle of moments of quantity of motion to an unevenly changing flow (in Russian), *Dokladi L'vovsk. Politekhn. In-ta* **2**, 1, 55-56, 1957; *Ref. Zh. Mekh.*, no. 3, 1958, Rev. 2901.

It was pointed out that in the work by A. Ya. Milovich ["Bases of hydromechanics," Moscow, Gosenergoizdat, 1946], when investigating the hydraulic jump, an incorrect application is made of the equation for the moments of quantity of motion (no account is taken of the moments of the forces of weight and the reactions of the bottom).

G. Yu. Stepanov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4551. Kaske, K., Considerations on the theory of hydrocyclones for washeries (in German), *Z VDI* **100**, 17, 717-721, June 1958.

For an ideal fluid, the combination of a sink and a vortex produces a spiral flow: the velocity v due to the vortex results from the relation $vr = C^1$ for a particle at a distance r of the axis of the vortex. For the flow of a real fluid in the hydrocyclones, measurements of Driessen and Kelsall give another relation: $vr^n = C^1$ with an average value of $n = 0.5$.

On the other side, the centrifugal force does not work with the same intensity on the fluid and on the solid particles in suspension. These last particles therefore take a motion in the fluid whose velocity c_n is influenced by the value of the Reynolds number $(C_n \cdot d)/\nu$; d is the diameter of the particles and ν the coefficient of cinematic viscosity of the fluid.

The value of the angle $tg\,\alpha = C_n/C$ is a criterion for the following different solutions (C is the velocity of the spiral flow of the liquid): (a) the solid particles reach the wall and the bottom orifice; (b) the solid particles are evacuated by the central overflow; (c) the spiral flows of the solid particles have a smaller angle than those of the fluid.

Author particularly discusses different characteristics of this last motion. L. J. Tison, Belgium

4552. Babnev, N. N., and Lentyakov, V. G., Influence of cavitation on the magnitude of the periodic forces transmitted to the ship's hull by a working screw propeller, *Sudostroenie* no. 5, 26–30, 1957; *Ref. Zh. Mekh.* no. 3, 1958, Rev. 2940.

An approximate method is demonstrated for the calculations of pulsating hydrodynamic pressures acting on the hull of a ship when the screw propellers are working, and the influence of cavitation is studied; this may make its appearance when the blades of the propellers pass through the zone of reduced velocities of the flow near the water level of the ship. It is shown that if this influence of cavitation is not taken into account then the calculated magnitude of the periodic forces may be magnified by actually 30 to 40%. The method is illustrated by numerical examples of the calculations carried out for four ships. A description is given of the procedure and results are given for the actual experiments of measuring the periodic forces on one of the fast ships. A possible method is referred to for reducing a ship's vibration by means of feeding atmospheric air into the region of the screw's disk.

Yu. M. Guliev

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

4553. Cheboevski, V. F., On cavitation in centrifugal pumps (in Russian), *Teploenergetika* no. 9, 12–16, Sept. 1957.

4554. Netushil, A. V., and Burdak, N. M., The modelling of an electro-osmotic fall in level (in Russian), *Zh. Tekhn. Fiz.* **26**, 7, 1595–1598, 1956; *Ref. Zh. Mekh.* no. 6, 1957, Rev. 6945.

4555. Zrelov, N. P., Method for extrapolational modelling of hydraulic processes (in Russian), *Trudi Gidravl. Sooruzh. i Inzhen. Gidrogeol.* no. 5, 5–15, 1957; *Ref. Zh. Mekh.* no. 3, 1958, Rev. 2887.

The method proposed by author consists of the determination of the relation of some characteristic of the scale-model in accordance with the investigational data derived from several models of various scales, and subsequent extrapolation of the relation obtained on the scale of the model of interest to us, which by this or other concepts can not be realized. The question is discussed of the selection of the scale for the model, and some examples are examined which are also of self-contained interest. Unfortunately, author makes no use of the concepts of dimensional analysis, the application of which would enable him to impart to his method a fully comprehensible meaning. G. I. Barenblatt

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

Incompressible Flow

(See also Rev. 4543, 4546, 4613, 4644, 4653, 4812)

4556. Lieber, P., Anderson, O., and Wan, K.-S., A principle of virtual displacements for real fluids (in English), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **2**, 106–112.

Variational principle is written for incompressible viscous flow which yields the Navier-Stokes equations as Euler equations. In the variation the stresses and body forces are held fixed and only the velocities are varied. Kinematic boundary conditions must be satisfied. Authors state that procedure is applicable only in cases where the flow field can be separated into rotational and irrotational regions.

Example application using a Rayleigh-Ritz type of procedure for the boundary layer on a flat plate is presented. Results compare well with those of Blasius and with experimental data.

J. M. Hedgepeth, USA

4557. Chernikin, V. I., Investigation of the motion of hot viscous petroleum in pipe systems (in Russian), *Trudî Mosk. Neft. In-ta* no. 17, 53–70, 1956; *Ref. Zh. Mekh.* no. 11, 1957, Rev. 12668.

It was found analytically that the curve $H = f(Q)$, the relationship of the pressure loss of H and discharge Q, for laminar motion of a hot liquid in a pipe system has three anomolous features: (1) a sharply defined maximum in the region of small values for Q and a minimum in the region of mean values for Q; (2) between the points max H and min H the pressure loss with increase of discharge decreases because of the increase of the temperature of the liquid in the tube system and of the sharp drop in its viscosity ν, during which ν drops more markedly than Q increases; (3) the same pressure value for H may correspond to three values of the discharge, but stable pumping is only possible for two of them. Curve $H = f(q)$ is well confirmed from experimental data.

A. D. Al'tshul'

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

4558. Heyda, J. F., A Green's function solution for the case of laminar incompressible flow between non-concentric circular cylinders, *J. Franklin Inst.* **267,** 1, 25–34, Jan. 1959.

Author examines laminar flow of an incompressible fluid between nonconcentric circular cylinders. For Poisson's differential equation $\Lambda^2 v = f$ [$v = v(x,y)$ = distribution of velocity in a nonconcentric annular cross section, $f = -(1/\mu) \cdot (dp/dl)$, (dp/dl) = pressure gradient, μ = coefficient of viscosity], Green's function in bi-polar coordinates for a nonconcentric annular region is derived. The application of bi-polar coordinates leads to a fairly simple form for Green's function. When the eccentricity of the annular region is assumed to approach zero, the distribution of velocity reduces to the well-known simple expression for the flow between two concentric circular cylinders. E. Niskanan, Finland

4559. Sokolov, Yu. D., Some particular solutions for Boussinesq's equation (in Ukrainian), *Ukr. Matem. Zh.* **8**, 1, 54–58, 1956; *Ref. Zh. Mekh.* no. 11, 1957, Rev. 12924.

Paper begins with a detailed exposition of the known particular solution of the Boussinesq equation, obtained by division of the variables. Then the author, by means of a different method, obtains a solution of the momentary source type, made known by G. I. Barenblatt [*Prikl. Mat. Mekh.* **16,** no. 1, 1952]. Author shows that in Barenblatt's paper the solution is given in an incorrect form. Actually, an investigation is being made known of a general problem on the automodel precise solutions of the equations for the motion of gases in a porous medium, when the expression of the solution being studied through the coordinate of the shifting boundary of the influencing region is correct, though in the expression for this coordinate in the cylindrical instance the indicator of degree is passed through twice in the denominator. In the concluding part of the paper being abstracted, the solutions in the form of $f(Ax + By + Ct)$ are examined; these solutions were investigated for the more general problems and for the particular case examined by the author in the work by G. I. Barenblatt [*Prikl. Mat. Mekh.* **17,** no. 6, 1953]. G. K. Mikhanlov

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

4560. Dolmatov, K. I., Suction of air through slots in pressurized pipe conduits (in Russian), *Dokladl Akad. Nauk UzbSSR* no. 5, 9–12, 1957; *Ref. Zh. Mekh.* no. 3, 1958, Rev. 2818.

The conditions which have to be satisfied by the form of a force tube and by the geometrical parameters of the slots in it to avoid air from the tube being blown out are determined. It was explained that, in order to guarantee the fulfillment of the named conditions for the flow, the tube must have a ledge at the place where the tube's opening or slots are situated. The experimental relation is found of the relative height of the ledge to Reynolds number R: $h = 5 \times 10^{-4} R - 0.09$. Yu. A. Lashkov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4561. Kharlamov, P. V., Two linear integrals of Kirchoff's equations (in Russian), *Trudl Donetsk. Industr. In-ta* **20**, 41–50, 1957; *Ref. Zh. Mekh.* no. 3, 1958, Rev. 2580.

The motion of a heavy solid body is investigated; the body is placed in an unbounded ideal homogeneous and incompressible liquid, assuming that the weight of the body is equal to the weight of the liquid displaced by the body, while the center of gravity of the body does not coincide with the center of gravity of the volume of liquid displaced. Chaplygin's investigations for the case where the equations of motion possess two joint linear integrals and both centers of gravity coincide, are extended by author to cover the case investigated by him. A. K. Nikitin

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4562. Melikyan, R. A., Hydrodynamics of emersion. I. Ascent of single bubbles in a liquid medium (in Russian), *J. Appl. Chem., USSR* **29**, 12, 1792–1802, Dec. 1956 (Translation of *Zh. Prikl. Khim.* **29**, 12, 1929–1938 by Consultants Bureau, N. Y.)

The hydrodynamics of the ascent of a single gas bubble in a liquid medium is discussed. Thermodynamic conditions are selected such that the energy of expansion released by the gas bubble in its ascent is equal to the energy converted by friction into heat. The interaction among bubbles in an ascending series of bubbles is also treated. The crowding effects tend to accelerate the ascent but this is somewhat compensated for by additional friction. The coalescence of small bubbles and the fragmentation of large ones introduce further complications. It is concluded that the ascent of bubbles is accompanied by an upward flow of continuous phase in the immediate vicinity of the bubbles and a downward flow of the remainder of the continuous phase. The theory is quantitatively supported by experimental data.

M. Baker, USA

4563. Uvarov, G. A., Entrainment of a liquid by a gas or vapour (in Russian), *Sb. Nauch. Trudl Kuibyshevsk. Industr. In-ta* no. 5, 196–203, 1955; *Ref. Zh. Mekh.* no. 3, 1958, Rev. 3064.

The problem is investigated of the entrainment of liquid by rising bubbles of gas in a stationary motion. The bubbles are taken to be solid bodies of spherical shape. It is assumed that the Reynolds number is sufficiently large and that when the bubble is flown about by the liquid a laminary boundary layer is formed. For purposes of computation of the quantity of entrained liquid the thickness is determined of the displacement in the boundary layer of the sphere. In so doing, it is assumed that the continuity of the flowing about is preserved and that the thickness of the displacement can be calculated, to a satisfactory degree of approximation, by the formulas for the boundary layer of a plane plate. The volume of the entrained liquid is taken to be equal to the volume occluded between the bubbles and the spherical surface, approximately representing the surface of the displacement thickness. The displacement thicknesses and, correspondingly, of the volumes of the entrained liquid depend on the speed of bubbling-up of the bubbles. In the paper use is made of the relations and experimental data determining the speed of bubbling-up when a quadratic regime of resistance is operating. The use of these data gives the opportunity to establish the dependence of the liquid volume, entrained by the bubbles, on its radius and on the physical properties of the liquid and gas. The relations obtained show that the relative quantity of liquid entrained by the gas increases with the breaking-down (in size) of the bubbles. Formulas (19) and (21) contain misprints. D. A. Efros

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4564. Curtet, R., Confined jets and recirculation phenomena with cold air, *Combustion and Flame* **2**, 4, 383–411, Dec. 1958.

Paper is directed at basic features of the dynamics of flame behavior in furnaces. It describes a theoretical and experimental study of constricted turbulent jet flow along ducts carrying steady streams of identical fluid. A general theory, based largely on basic assumptions, is given for the mean flow, and experiments with air and water models are described. Theory indicates presence of recirculating eddy near the wall if duct is long enough, and predicts position of upstream edge of eddy.

Reviewer considers paper an interesting contribution on jet mixing, but regrets that parts of theory are not more fully argued, specially to bring out physical significance of some steps.

B. R. Morton, England

4565. Khamrui, S. R., On the flow of a viscous liquid through a tube of elliptic section under exponential pressure gradient, *Bull. Calcutta Math. Soc.* **49**, 3, 147–152, Sept. 1957.

The flow of a viscous liquid through a tube of elliptic section under a pressure gradient which varies exponentially with time is discussed. Solutions are obtained in two cases: (1) when the pressure gradient is exponentially increasing, (2) when the pressure gradient is exponentially decreasing; and from them the results in two extreme cases are deduced.

From author's summary by H. C. Levey, Australia

Compressible Flow (Continuum and Noncontinuum Flow)

(See also Revs. 4265, 4284, 4332, 4440, 4627, 4628, 4646, 4660, 4667, 4676, 4691, 4692, 4709, 4737, 4752, 4753, 4766, 4769, 4787)

4566. Power, G., and Smith, P., A modified tangent-gas approximation for two-dimensional steady flow, *J. Fluid Mech.* **4**, 6, 600–606, Nov. 1958.

Authors suggest a better method for constructing a tangent-gas approximation, thus yielding greater accuracy over a wider range of subsonic flow. Application may be applied to any two-dimensional, subsonic, isentropic flow over certain cylinders.

Tsien [*J. Aero. Sci.* **6**, 10, 399–407, Aug. 1939], reduced the hodograph equations for two-dimensional compressible flow to an equivalent incompressible flow problem. The possibility in so doing was due to approximating the isentrope $pv^{\gamma} = \text{const}$ by a tangent line $p = a - bv$. Tsien chose the free-stream conditions as the point of tangency.

Authors discuss how variation in choice of point of tangency changes resulting compressible flow approximation. They show that picking stagnation conditions as point of tangency results in underestimation of surface velocities, while picking the sonic conditions as point of tangency results in overestimation of surface velocities. As a result, authors suggest that a straight line fit to the isentrope, by a least-squares method, from stagnation conditions to sonic conditions, possibly gives best results.

Computations are presented showing a comparison of authors' results and those of Tsien with accurate results obtained by Lush and Cherry [AMR **9** (1956), Rev. 3683] using a variational approach. Compressible flow past a circular cylinder was considered. Authors' least-squares approximation does appear to reproduce Lush and Cherry's results very well while the Kármán-Tsien approximation underestimates the surface velocity near the point of maximum velocity by about 5-10%.

Reviewer believes work to be correct and to add more dimension to tangent-gas approximation. A. Kovitz, USA

4567. Moriguchi, H., Some nonlinear effects in compressible flow, *J. Phys. Soc. Japan* **13,** 12, 1510-1516, Dec. 1958.

Imai's method, based on an expansion in powers of M^2, is used to calculate the two-dimensional subsonic potential flow past a two-parameter family of profiles having streamwise and transverse planes of symmetry. Profiles include ellipse and Kaplan bump. General solution for surface velocities is given up to terms of order M^2. Author finds that velocity maxima occur either at mid-profile or at two streamwise locations. He shows that, at least in approximation given, in some profiles it is possible that velocity distribution changes from two maxima to one maximum as Mach number increases. However, for these profiles the peak is very flat, and author suggests that the changeover, if it occurs at all, may not be very noticeable. I. Greber, USA

4568. Lehrian, Doris E., Calculated derivatives for rectangular wings oscillating in compressible subsonic flow, *Aero. Res. Counc. Lond. Rep. Mem.* 3068, 9 pp. + 2 tables + 7 figs., 1958.

Stability and flutter derivatives are obtained for rectangular wings describing plunging and pitching oscillations in subsonic flow. These are evaluated by applying the simple approximate "equivalent" wing theory [*Aero. Res. Counc. Lond. Rep. Mem* 2855] with the vortex-lattice method of downwash calculation. The derivatives for the wing of aspect ratio 4 at Mach number 0.866 are compared with values calculated by a method based on exact theory; at this high Mach number it is found that the present method is sufficiently accurate for only a very limited range of the frequency parameter. At very low values, the pitching-moment derivatives for this wing are in reasonable agreement with those calculated by the Multhopp-Garner method and with results from wind-tunnel tests at high subsonic Mach number.

From author's summary

4569. Alford, W. J., Jr., Theoretical and experimental investigation of the subsonic-flow fields beneath swept and unswept wings, with tables of vortex-induced velocities, *NACA Rep.* 1327, 28 pp. + 5 tables, 1957.

See AMR **10** (1957), Rev. 194.

4570. McCune, J. E., The transonic flow field of an axial compressor blade row, *J. Aero/Space Sci.* **25,** 10, 616-626, Oct. 1958.

This is the second in a series of two papers. Basic equation is derived in first paper [*J. Aero. Sci.* **25,** 9, 544-560, 1958]; its application to transonic flow is discussed in this one. Because of occurrence of resonance in transonic flow, theory is modified to include first-order viscous and heat-conduction effects to permit linear treatment. This results in a potential solution with viscosity. Author argues that such a solution has meaning since no mechanism for producing first-order vorticity is present except in boundary layers. He also considers it justifiable to include first-order viscous terms while neglecting higher-order inertia terms, although this is now shown mathematically.

Numerical examples were worked out to show pressure distribution over blades of a somewhat idealized, nonlifting blade row. Tip Mach numbers were 0.98, 1.00, 1.033, 1.05, 1.071 and 1.09. Results indicate a smooth transition from subsonic to transonic flow. However, in the transonic regime (tip Mach numbers 1.033, 1.05 and 1.071), the pressure distributions are strongly influenced by acoustic resonance and interference between blades. Author believes that, in this regime, two-dimensional blade-element theory is completely inadequate. He also finds that viscous effects are important only in a very narrow range of Mach number for each resonant made; and that the significant tip Mach number is not unity, but slightly over unity, when the fundamental mode becomes resonant.

Reviewer thinks the paper represents a very capable piece of theoretical analysis. Its value would be enhanced, however, if a few comparisons with experiment had been included.

T. C. Tsu, USA

4571. Sheppard, L. M., The wave drag of non-lifting combinations of thin wings and "non-slender" bodies, *Aero. Res. Counc. Lond. Rep. Mem.* 3076, 15 pp. + 4 figs., 1958.

Determination of minimum wave drag of wing-body combination had been made by R. T. Jones, then Lomax and Heaslet extended the area rule to wing-body combinations incorporating such non-slender fuselages as can be represented by smooth axial distributions of multipole singularities. This extension was not fully satisfactory due to certain inconsistency in assumptions. Present paper makes use of an alternate multipole method based on the assumption, fundamental to the area rule and transfer rule, that effect on the wave drag of the interference velocity potential, due to interaction between the exposed wing and fuselage, is negligible. Validity of this assumption has been investigated using three known results of supersonic linearized theory for wing-body combination. An approximate equation for theoretical minimum wave drag is given and a graph shows the importance of fuselage quadrupoles in reducing the wave drag of wing-body combination. Minimum drag is also found for axisymmetrical fuselage. It is shown that the usefulness of multipole method does not decrease with increasing Mach number. The accuracy of predictions has been examined. P. Bielkowicz, USA

4572. Frankl', F. I., Transonic flow with local supersonic zones (in Russian), *Trudi 3-go Vses. Matem. S'ezda*, Vol. I, Moscow, Akad. Nauk SSSR, 1956, 213-214; *Ref. Zh. Mekh.* no. 11, 1957, Rev. 12510.

For a considerable time no success was attained in producing an example of flow with a final supersonic region, ending with a compression jump and in contact with only one wall. In his work in 1955 the author gave such an example, which may be presented in the form of a simple formula $\psi = \text{const}\ (\eta^+ - 6\theta^2\eta)$, where ψ is the function of the current, η the function of the modulus of velocity and θ the angle of inclination of the velocity. The supersonic zone in this case ends downstream with a direct compression shock. The example is based on the application of the hodograph method of Molenbruk-Chaplygin in combination with the theory of equations in particular derivatives of the mixed type, the treatment of which was commenced by Trikom; that theory is applied to the equation

$$\eta \frac{\partial^2\psi}{\partial\theta^2} + \frac{\partial^2\psi}{\partial\eta^2} = 0$$

In further work, author formulated the border problem, enabling a construction to be made of the flow past outline of a plane parallel stream of transonic velocity to infinity with a supersonic zone of the given form. The boundary problem merges with Fredholm's integral equation of the second order. In this, account is taken of the conditions of the compression shock, in contrast to the work of some other authors (Cole, Trilling, Walker) where these conditions are not considered.

From author's summary

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

4573. Runyan, H. L., and Woolston, D. S., Method for calculating the aerodynamic loading on an oscillating finite wing in subsonic flow, *NACA Rep.* 1322, 30 pp., 1957.

See AMR **10** (1957), Rev. 512.

4574. Presley, L. L., and Mossman, E. A., A study of several theoretical methods for computing the zero-lift wave drag of a family of open-nosed bodies of revolution in the Mach number range of 2.0 to 4.0, *NACA TN* 4368, 23 pp. + 17 figs., Sept. 1958.

Wave drags of a family of open-nosed bodies were calculated by (1) first-order and (2) second-order perturbation theory; (3) generalized and (4) second-order shock expansion theory; (5) tangent-wedge theory; (6) impact theory; and (7) method of characteristics. Methods (1)–(6) are summarized in report. Methods (2) and (4) gave best agreement with (7). Method (4) requires less computational effort than (2). Wave drags of bodies with fixed lip angle and fixed ratio of maximum diameter to inlet diameter increase sharply with fineness ratio (f.r.) for f.r. less than 3, and remain nearly constant for f.r. above 3. An appendix outlines a form of (7) suitable for automatic computers. J. H. Giese, USA

4575. Cahn, M. S., and Olstad, W. B., A numerical method for evaluating wave drag, *NACA TN* 4258, 8 pp. + 2 tables + 2 figs., June 1958.

The double integral

$$\int_0^l \int_0^x S''(x)\, S''(\xi) \log (x - \xi)\, d\xi\, dx$$

is evaluated by integrating first along $x - \xi = \text{const}$, with respect to x from x to l, and secondly with respect to $x - \xi$, from 0 to l.

The corresponding numerical procedure (of mechanical cubature) employs a parallelogram mesh, in the $x - \xi$ plane, which is obtained by dividing the triangular area, bounded by $x = \xi$, $\xi = 0$, and $x = l$ into equal intervals parallel to $x = \xi$ and $\xi = 0$, respectively. After calculating the second derivative, $S''(x)$, at the mid-point of each interval of $0 \leqslant x \leqslant l$, the product $S''(x)\, S''(\xi)$ is summed along each strip parallel to $x = \xi$, multiplied by a weighting factor L_j, and the results summed to evaluate the integral. Use of the integrated value of $\log (x - \xi)$ across a strip parallel to $x = \xi$ as weighting factor L_j absorbs the singularity along $x = \xi$. Further, since the weighting factors are independent of scale and the number of intervals used, values of L_j tabulated in the *Note* are sufficient for all cases with not more than 100 intervals.

A particular application of this integral to the evaluation of supersonic wave drag of a body of revolution is exemplified by four configurations which include protrubrances and waisting.

It is also shown that the second derivatives of $S(x)$ may usually be replaced by second differences without causing greater numerical errors than are already inherent in linearized aerodynamic theory.

This method provides a simple computational technique and has been programmed to evaluate the supersonic wave drag of a body of revolution, using 100 cross-sectional areas, on a computer of megacycle digit frequency in under two minutes.

It is unfortunate that the author uses $S''(x)$ to represent second derivative on pp. 2–4, twice a second divided difference on p. 6, and second derivative divided by $32\,\pi\, R^2/l^2$ on p. 10.

S. Kirkby, England

4576. Stetter, H. J., Supersonic flow around quasi-conical bodies, with application to wing-body interference, AFOSR TN 58-167 (Technische Hochschule, Munchen, TN 3; ASTIA AD 157-194), 24 pp., 1958.

The "quasi-cylindrical" theory described in AMR **10** (1957), Revs. 504 and 4090 is generalized to a "quasi-conical" theory. Behind a certain section of the body, the conical flow is perturbed, either from slight deformation of the conical surface or the presence of wings, etc.

The perturbation flow potential is Fourier-analyzed for azimuthal angle. Each Fourier component is then expressed as an integral transform of the boundary disturbance function. The kernels are functions of two space variables, and have cone semi-angle and Fourier component number as parameters, making tabulation a formidable undertaking.

Alternatively, the problem is reduced to a quasi-cylindrical problem, with the boundary disturbance function yielded by solution of a Volterra integral equation. Reviewer notes that the latter method of treatment is not restricted to quasi-conical bodies.

A wing-body interference problem is worked as an example of the application of this useful and straightforward paper.

Reviewer suspects an error of sign in the second of equations (2.5). A. H. Armstrong, England

4577. Carafoli, E., and Nastase, Adriana, Study of thin triangular wings with forced symmetry in supersonic stream (in Roumanian), *Studii si Cercetari Mecan. Appl.* **9**, 4, 233–253, 1958.

Paper determines the aerodynamic characteristics of thin symmetrical triangular wings within the theory of high-order conical flows, admitting that the incidence (the vertical component of the disturbance velocity respectively) has a forced symmetry. Proceeding from the idea that the disturbance downwash is generally set under the form of an homogeneous polynomial of n-l order, authors define the natural symmetry as being that reached when the polynomial includes only even terms and the forced symmetry as that given by a polynomial which has only odd terms and of different sign on the two symmetric halves of the wing. Within this latter class are situated the triangular wings with a ridge placed on the symmetry axis. The expression of the axial disturbance velocity is determined for the conical motion of n order and the results are particularized when $n = 2,3,4$ both for natural and for forced symmetry. The drag and lift coefficients are calculated under the same conditions. Finally, the expression of the suction force occurring at thin wings with subsonic leading edges is determined. T. Oroveanu, Roumania

4578. Parthasarathy, R., Study of drag reduction of high-wing configurations at supersonic speeds, AFOSR TN 58-837 (Polyt. Inst. Brooklyn, Aero. Lab. Rep. 456; ASTIA AD 203 001), 14 pp. + 7 figs., Oct. 1958.

The purpose of the present report is to show the possibility of drag reduction of wing-body combinations at all practical values of the lift coefficient, by a proper distribution of the body volume. This is illustrated by modifying a midwing configuration, composed of a full circular cone, symmetrically disposed about the swept wing of zero thickness, to a high-wing configuration, composed of the same wing, but two half cones of equal volume as the full cone, mounted beneath the wing. It is found that at Mach number equal to 3.0 and lift coefficient equal to 0.1, for a cone of semi-vertex angle $\Theta_c = 5°$, the high-wing configuration gives a drag reduction of 16% over that of the corresponding midwing configuration, whereas there is found to be a drag reduction of 6.5% at Mach number equal to $\sqrt{2}$. Similar comparison for the percentage increase in lift-drag ratio for the above-mentioned configurations shows a maximum increase of 34% at a Mach number equal to 3.0 for the high-wing configuration over the midwing configuration, whereas it is 22% at a Mach number equal to $\sqrt{2}$. Numerical results show that the high-wing configuration gives a significant reduction in drag as compared to a midwing configuration of equal volume and, furthermore, greater reductions in drag are obtained at higher Mach numbers.

From author's summary

4579. Visich, M., Jr., and Martellucci, A., Theoretical and experimental analysis of a cowling as a means of drag reduction for an axisymmetric center body, AFOSR TN 58 760 (Polyt. Inst. Brooklyn, Aero. Lab. Rep. 451; ASTIA AD 162 273), 13 pp. + 2 tables + 18 figs., Aug. 1958.

A theoretical and experimental investigation at a Mach number of 3.09 of an axisymmetric boattailed center body surrounded by a cowling ring has been conducted at the Polytechnic Institute of Brooklyn Aerodynamics Laboratory. The design of the body was accomplished by the method of characteristics for axisymmetric irrotational flow for zero angle of attack. The test Reynolds number per foot for the entire program was 3.37×10^7 and the flight attitude for the tests was at zero angle of attack.

The configuration studied can be used as an independent flight vehicle with a circular wing. It can also be used as an auxiliary ramjet engine or external storage system for long-range vehicles. For the optimum configuration considered, a total drag reduction of 61.8% was measured over the center body alone. Comparison of the total drag of the optimum configuration to that of a cone with the same volume and length as the center body indicates a reduction of 47%.

The method of design, a description of the experimental equipment, discussion of the test results and the possible applications of the system are presented. From authors' summary

4580. Ting, L., Some aspects of drag reduction for lifting wing-body combinations at supersonic speed, AFOSR TN 58 423 (Polyt. Inst. Brooklyn, Aero. Lab. Rep. 445; ASTIA AD 158 226), 13 pp. + 2 tables + 12 figs., May 1958.

It has been shown that favorable antisymmetric modifications of the fuselage near the midwing can provide significant drag reductions in lifting wing-body combinations. The investigation of the present report shows that for a prismatic body of rectangular cross section with given volume (or cross section area) mounted on a midwing of given span and sweep back, the lift-drag ratio of the wing-body combination with the favorable antisymmetric modifications will be higher if the basic body has a lower height-width ratio. For bodies with height-width ratio equal to 1 to 2, the favorably contoured wing-body combination has almost the same value of lift-drag ratio as that of a favorable planar lifting surface which possesses zero volume and is composed of the wing and the projection of the body on the plane of the wing. With further increase in the height-width ratio the lift-drag ratio of the favorably contoured wing-body configurations, with the same projected planform, decreases slightly while the volume increases linearly with the height-width ratio.

For the wing-body configurations studied in the present report, the effect of contouring the vertical surface which does not support lift will result in an increase of 5 to 10% in the lift-drag ratio, depending on the height-width ratio and also the ratio of the area of the lifting (horizontal) surface to that of the non-lifting (vertical) surface.

Calculations for a simple model of wing-body combination are made to study the effect of favorable interference at off-design conditions. The result shows that for a given value of $C_L\sqrt{M^2-1}$ the drag increases gradually as the free-stream Mach number deviates from the designed value. For given value of C_L, the drag varies in the same manner as a planar wing when the Mach number deviates from the designed value.

From author's summary

4581. Martellucci, A., A theoretical and experimental investigation at a Mach number of 3.09 of a low-drag auxiliary body utilizing favorable interference, AFOSR TN 58 175 (Polyt. Inst. Brooklyn, Aero. Lab. Rep. 432; ASTIA AD 152 208), 30 pp. + 2 tables + 18 figs., Dec. 1957.

An experimental investigation at a Mach number of 3.09 of a low-drag auxiliary body, zero lift system, has been conducted at the Polytechnic Institute of Brooklyn Aerodynamics Laboratory. The design of the body was carried out by nonlinear methods of flow analysis. The test Reynolds number per foot for the entire program was 3.37×10^7.

The body can be applied to the problem of external storage under a wing or as an auxiliary ramjet engine to be used, for example, during acceleration. A drag coefficient of 0.0094 based on a reference area (maximum cross-sectional area) of 2.120 square inches was determined experimentally for the body in the proximity of the wing. The capture area of the body is 3.53 square inches and the Mach number at the minimum section is 1.6.

The method of design, a description of the test setup, discussion of the test results and the possible applications of the system are presented in this report. From author's summary

4582. Rhyming, I., Axial upstream effect of supersonic cascades of airfoils (in German), *ZAMM* **37,** 9/10, 371–385, Sept./Oct. 1957.

This theoretical paper treats supersonic flow conditions out of guide vanes into the rotating turbine blades. By the method of characteristics the conditions for expanding as well as for compression flow are shown. Comparison with exact theory shows great deviation in some cases. When the normal component of the flow has a Mach number < 1 Mach waves are propagated upstream from the rotating blades, thus influencing the incoming flow.

M. Rand, Canada

4583. Tomlin, S., and Stanbrook, A., Effects of some changes in body length and nose shape on the aerodynamic characteristics of wing-body combinations at supersonic speeds, *Aero. Res. Counc. Lond. Curr. Pap.* 413, 4 pp. + 3 figs., 1958.

Three bodies have been tested alone and in combination with each of two wings, at Mach numbers of 1.42 and 1.61, to find the effect of body length and nose shape on the aerodynamic characteristics of the wing-body combinations. The increments in the forces and moment resulting from the addition of the wing to the body varied little with the different body shapes tested.

From authors' summary

4584. Garner, H. C., Numerical aspects of unsteady lifting-surface theory at supersonic speeds, *Aero. Res. Counc. Lond. Curr. Pap.* 398, 6 pp., 1958.

4585. Bobbitt, P. J., Linearized lifting-surface and lifting-line evaluations of sidewash behind rolling triangular wings at supersonic speeds, *NACA Rep.* 1301, 19 pp., 1957.

See AMR **9** (1956), Rev. 2983.

4586. Creager, M. O., The effect of leading-edge sweep and surface inclination on the hypersonic flow field over a blunt flat plate, *NASA Memo* 12-26-58A, 45 pp., Jan. 1959.

The interaction of viscous and inviscid portions of a flow field is apparent at high Mach and low Reynolds numbers. Extension is made here to the combined effects of sweepback and angle of attack for a semicylindrical blunt plate using blast-wave and (sharp) flat plate hypersonic viscous first-order results. The assumption of independent and linearly additive contributions for pressure distribution is within 10% agreement with experimental data over an extremely wide range of Mach and Reynolds numbers, edge thickness, sweepback, and inclination. Both boundary-layer thickness and shock-wave shape prove nearly independent of sweepback. J. R. Baron, USA

4587. Bogdonoff, S. M., and Vas, I. E., Preliminary investigations of spiked bodies at hypersonic speeds, *J. Aero/Space Sci.* **26,** 2, 65–74, Feb. 1959.

An experimental examination has been made of the flow over blunt bodies equipped with a spike. These tests, carried out at a

Mach number of about 14 in the Princeton Helium Hypersonic Tunnel, have investigated the effect of varying spike lengths for flat-faced and hemispherically-nosed axially symmetric bodies. The results show that the use of a spike protruding from a hemispherical-nosed cylinder at $M = 14$ decreased the pressure level by an order of magnitude and the heat transfer to a fraction of that measured on a hemisphere without a spike.

From authors' summary by J. V. Becker, USA

4588. Serbin, H., The high speed flow of gas around blunt bodies, *Aero. Quart.* **9,** 4, 313–330, Nov. 1958.

Paper gives approximate analysis of shape and location of shock ahead of sphere and circular disk. Well-known hypersonic limit approximation is used and it is assumed that the shock and flow angles to the vertical behave like $K^{-\frac{1}{2}}$ where K is density ratio across shock. The shock shape and downstream subsonic flow field are found and it is shown that the Mach number is constant along each streamline. This result is ignored in calculating the shock location by integration along the sonic line. Consideration of stand-off distance for K near unity is used to justify replacement of K by $K - 1$ in formulas to yield results that agree well with experiment.

Reviewer notes that results do not agree with those of more rigorous treatments [Chester, AMR **10** (1957), Rev. 3696; Freeman, AMR **10** (1957), Rev. 3704] based on hypersonic limit approximation.

D. G. Hurley, Australia

4589. Gonor, A. L., Flow about a cone at an angle of attack at large supersonic speed (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 7, 102–105, 1958.

Author considers the problem of a flow around a cone at a certain angle of attack in hypersonic regime. The starting point consists of equations of classical gasdynamics in spherical coordinates which are modified by introducing a function analogous to the stream function in a two-dimensional motion. The resulting system of equations is solved by the method of Czernyi, i.e., expansion in series in $\varepsilon = (j - 1)/(j + 1)$. The first approximation is easily calculated using the values of the incoming flow (velocity, dynamic pressure, etc.) as the initial values. As a particular case, author considers the case of $M \to \infty$, $\varepsilon \to 1$, i.e., Newtonian flow. The first approximation to the pressure coefficient is analogous to that obtained by Ivey and Morrissette [*NACA TN* 1740, 1948], Grimminger, and others. A diagram of C_p shows a comparison between the values obtained by the present method and by some previous authors. The agreement is fair. Higher-order terms can be obtained by means of quadratures up to the required degree of approximation.

M. Z. Krzywoblocki, USA

4590. Dorleac, B., Heat effects on structures at supersonic and hypersonic speeds (in French) *AGARD Rep.* 149, 28 pp. + 10 tables + 48 figs. + 4 appendixes, Nov. 1957.

The paper is in two parts. The first part indicates some structural problems and design types investigated in France during the past few years, while the second part refers to structural problems of the future.

From author's summary

4591. Zakkay, V., Pressure and laminar heat transfer results in three-dimensional hypersonic flow, WADC TN 58–182, (Polyt. Inst. Brooklyn, Dept. Aero. Engng. Appl. Mech.; ASTIA AD 155 679), 58 pp., Sept. 1958.

An experimental investigation of the pressure and heat transfer distribution in hypersonic flow has been carried out.

First there is presented a brief review of the methods of analysis available for the pressure and heat-transfer distribution on axially symmetric cones at angles of attack. An approximate method for determining the peripheral pressure distribution about axially symmetric blunted cones at an angle of attack is developed.

Tests were performed at a Mach number of 6.0 in the hypersonic facility of the PIBAL to determine the heat-transfer and pressure distribution over a blunted axially symmetric body at various angles of attack. The measurements are compared with existing theories, and particularly with the recently developed theory of Vaglio-Laurin.

In an appendix, a method for determining the crossflow velocity gradient $(\partial w/\partial \varphi)$ from the peripheral pressure distribution is included.

From author's summary

4592. Zakkay, V., and Fields, A. K., Pressure distributions on a two-dimensional blunt-nosed body at various angles of attack, AFOSR TN 58 1016 (Polyt. Inst. Brooklyn, Aero. Lab. Rep. 461; ASTIA AD 162 281), 7 pp. + 12 figs., Oct. 1958.

Pressure distributions on a two-dimensional blunt-nosed body at angles of attack have been determined at a Mach number of 6.0 in the hypersonic facility of the Polytechnic Institute of Brooklyn Aerodynamics Laboratory.

The pressure distribution results and the velocity gradient at the stagnation point are compared with the theoretical predictions.

It is shown that the Newtonian theory does not apply for bodies where the sonic point does not fall on the same radius of curvature as the stagnation point. A large reduction in stagnation-point heat transfer was obtained as a result of increasing the radius of curvature of the body at the sonic point over that which exists at the stagnation point of constant-radius-of-curvature models.

From authors' summary

4593. Ferri, A., A review of some recent developments in hypersonic flow, WADC TN 58–230 (Polyt. Inst. Brooklyn, Aero. Lab. Rep.; ASTIA AD 155 822), 75 pp., Sept. 1958.

The problems connected with hypersonic flows are reviewed. First, those connected with nonideal gas behavior are shown to be not of great importance at the present time compared to the lack of information concerning other aspects of hypersonic flow. The problem of pressure distribution on blunt-nosed bodies is discussed and the importance of the sonic line pointed out. The pressure distribution in three-dimensional flows is discussed; for example, the flow about an axially symmetric body at an angle of attack is described. The present status of laminar and turbulent heat-transfer calculations for hypersonic conditions is reviewed. The important effects of entropy on boundary-layer characteristics are pointed out. In these several problem areas experimental data obtained at PIBAL are presented.

From author's summary

4594. Bird, G.A., The effect of wall shape on the degree of reinforcement of a shock wave moving into a converging channel, *J. Fluid Mech.* **5,** 1, 60–66, Jan. 1959.

It has been known for some time (e.g., "Shock-tube-theory and applications," Nat. Aero. Establ. Rep. 15, 1952, by this reviewer) that shock amplification would result from a decrease of channel area. In this paper, theoretical amplifications are computed for area changes made in one or more steps and are compared with experimental measurements made in an air (driver) - argon (driven) shock tube, fitted with different shapes of the area-transition section. With a smooth transition shape, the transmitted shock-pressure ratio approached the theoretical value (for an infinite number of steps) within 10% and was 1.83 times the amplification obtained with one, abrupt area discontinuity.

J. Lukasiewicz, USA

4595. Honda, M., A theoretical investigation of the interaction between shock waves and boundary layers, *J. Aero/Space Sci.* **25,** 11, 667–678, Nov. 1958.

The interaction process between shock waves and boundary layers is treated by author as a self-inducing type of flow, determined by an equilibrium between the induced pressure rise

and the thickening of the boundary layer. On such a basis, the development of the laminar boundary layer is described by momentum and energy-integral equations, giving results to be compared favorably with known experiments. The development of the turbulent boundary layer with adverse pressure gradients in compressible fluid flow is treated semiempirically on the usual boundary-layer assumption of the incompressible flow, but the application of the resulting calculating formulas to the subject shows the inadequacy of this assumption. Consequently, the layer is divided by author in two regions, one the inner viscous layer adjacent to the wall and the other the outer inviscid layer; the growth of the inner layer following Kármán's similarity law is then determined by the flow conditions at the edge of the outer layer. The obtained results agree fairly well with those of experiments.

In addition to references by the author, reviewer would quote a recent contribution by B. Bertotti [*R. C. Ist. Lomb., Sci. Mat. Nat.* (*A*) **92**, p. 132, 1957] giving a somewhat different approach for the interaction with a nonseparated boundary layer.

A. Ghetti, Italy

4596. Stollery, J. L., and Maull, D. J., A note on the compression of air through repeated shock waves, *J. Fluid Mech.* **4**, 6, 650–654, Nov. 1958.

The results of calculations of the compression of air by repeated shock waves are compared with the perfect-gas values given by Evans & Evans (1956). The comparison emphasizes the increasing divergence of real from perfect-gas results as shock strengths are raised. The equations relating conditions across a shock wave are obtained in a convenient form for solution using a Mollier diagram.

From authors' summary

4597. Chen, T., Two-dimensional oblique shock calculations in a hypersonic diffuser, Purdue Univ., School of Aero. Engng. Rep. A-58-7, 25 pp., Nov. 1958.

Report is concerned with oblique shock-configuration diffusers of hypersonic wind tunnels.

For test section Mach numbers up to 5, the standard NACA charts for compressible flow can be used for diffuser calculations. However, at higher velocities, dissociation takes place as the temperature of the air is raised in passing through a shock wave.

The purpose of this investigation is to determine the dissociation effect on recovery pressure in order to assess the advantage of the oblique shock configuration over the normal shock diffuser.

The typical case of a sequence of two oblique shocks is studied here; the graphical method developed by G. A. Bird is used.

Calculations of recovery pressure have been carried out based on two conditions at the test section; one for an altitude of 100,000 ft with a Mach number of 10, and the other for an altitude of 150,000 ft with a Mach number of 15.

A typical calculation of recovery pressure ratio has been given in the Appendix. From author's summary

4598. Liepmann, H. W., and Skinner, G. T., On a study of strong cylindrical shock waves from electrically exploded filaments (in English), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **2**, 101–103.

Problem of producing high temperatures and strong cylindrical shock waves from exploding thin wires by passing a high voltage discharge through them is considered. A new experimental procedure designed to overcome difficulties in producing a very strong shock with a single discharge is outlined, and experimental work on the determination of the practicality of the method is described. Preliminary experimental work indicates that method can be successfully applied. M. L. Baron, USA

4599. Hasimoto, Z., Some local properties of plane flow behind a curved shock wave (in English), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **2**, 118–125.

Author discusses three aspects of the properties of the plane steady flow of a gas behind curved shock waves of regular shape. The gas is assumed to be adiabatic and the flow in front of the shock wave is uniform. Pressure distribution along streamlines, flow in the neighborhood of the sonic point of the shock wave, and flow in the neighborhood of an inflection point on the shock wave are treated analytically. Possible singular behavior of the hodograph transformation is discussed.

M. L. Baron, USA

4600. Talbot, L., and Sherman, F. S., Structure of weak shock waves in a monatomic gas (in English), 9th Congrès Intern. Mécan. Appl., Univ. Bruxelles, 1957; **2**, 126–136.

A new experimental technique by Sherman for measuring shock-wave structure by means of a free molecule probe is applied to shock waves in argon at Mach numbers of 1.335, 1.454, 1.576, 1.713. Data obtained consist of wire temperature profiles, i. e. the variation of wire equilibrium temperature with position through the shock wave, which are related by kinetic theory to local flow properties. Experimental shock profiles are compared with theoretical results obtained from the Navier-Stokes equations and two higher-order kinetic theory approximations, the Chapman-Enskog method and the Grad 13-Moment method. Authors found the experimental shock profiles to be in better agreement with the results from the Navier-Stokes equations than with those of the higher-order theories, both with regard to maximum slope thickness and overall profile shape. M. L. Baron, USA

4601. Chernyi, G. G., Adiabatic motions of an ideal gas with shock waves of great intensity (in Russian), Trudí 3-go Vses. Matem. S'ezda, Vol. 1 Moscow, Akad. Nauk SSSR, 1956, 215–216; *Ref. Zh. Mekh.* no. 11, 1957, Rev. 12511.

It is assumed that in some layer of the gas the density is considerably greater than the density on the remaining zone of motion. To measure the density ρ inside the layer, a new scale of measurement $\rho = \rho'/\varepsilon$, where the small value ε is such that ρ' is of the same order as the density outside the layer. By substituting value ρ'/ε for ρ in the equations of motion, author seeks the solution of the equations in the form of series by powers of ε. In conception, this method is analogous to Mises's method of obtaining the equations in the theory of the boundary layer from the equations of the motion of a viscous liquid by presenting the solution in the form of series by powers of $1/R$, where R is the Reynolds number (the equations of the theory of the boundary layer determine the first terms of these series). The motion of the ideal gas depending on two variables is investigated. In the case of unsteady one-dimensional motions Lagrange variables selected by a special process are brought in to represent the independent variables, while in the case of steady plane or axially-symmetrical motions the function of the current is taken to represent one of the independent variables. In such variables the progressive terms of the series of powers of ε are expressed by simple formulas containing arbitrary functions. The problem of finding the motions of the gas becomes linked with that of finding the arbitrary functions from the boundary and original conditions. To the flows of the form being investigated are referred the flows of an ideal gas with shock waves of great intensity, in which a significant amount of compression takes place. For very powerful waves the ratio of the densities of the gas upstream and downstream from the wave is determined by the value $(\gamma + 1)/(\gamma - 1)$, where γ is the ratio of specific heats; for air $\gamma = 1.4$. From author's summary

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

4602. Lun'kin, Iu. P., Entropy change during relaxation of a gas behind a shock wave, *Soviet Phys.-JETP* **7, 6,** 1053–1055, Dec. 1958. (Translation of *Zh. Eksp. Teor. Fiz.* **34,** 6, 1526–1530, June 1958 by Amer. Inst. Phys., Inc., New York, N. Y.)

Investigation is made of entropy changes which take place in shock waves as translational, rotational and vibrational degrees of freedom are successively excited and as dissociation is induced. It is shown that the largest entropy change takes place when the translational degrees of freedom are excited; excitation of other degrees of freedom involves smaller entropy variations. From author's summary by E. W. Price, USA

4603. Freeman, N. C., Non-equilibrium flow of an ideal dissociating gas, *J. Fluid Mech.* **4,** 407–425, Aug. 1958.

Behavior of an "ideal dissociating" gas is investigated for flow through a strong normal shock and past a bluff body. Excitation of rotational and vibrational degrees of freedom is assumed complete in an infinitesimally thin region according to Rankine-Hugoniot shock-wave relations before dissociation begins. Net rate of dissociation is then obtained by subtracting a recombination term (based on 3-body collisions at rate proportional to square of density of free atoms) from a dissociation term (based on simple rate expression). This equation contains "equilibrium" parameters of the Lighthill theory [title source **2,** no. 1, Jan. 1957] plus a "non-equilibrium" parameter which determines the time scale for dissociation.

Variation of relevant thermodynamic variables is computed for a few cases by an extension of the Newtonian theory of hypersonic inviscid flow. For a sphere, the variation of shock shape and stand-off distance with Λ (ratio of sphere diameter to length scale of dissociation process) is shown for conditions extending from undissociated flow to dissociated flow in thermal equilibrium. Results suggest that stand-off distance could increase as much as 50% if equilibrium were obtained, as compared to undissociated case; therefore appreciable changes in the geometry of the flow field may be expected. However, values for the non-equilibrium parameter are not presently available.

Reviewer believes this contribution should be valuable to investigators of flow around leading edges of hypersonic vehicles and particularly for reentry bodies. G. L. Dugger, USA

4604. Gherman, O., Kinetic theory of the flow of a gas through a cylindrical tube, *Soviet Phys.-JETP* **7,** 6, 1016–1119, Dec. 1958. (Translation of *Zh. Eksp. Theor. Fiz.* **34,** 6, 1470–1474, June 1958 by Amer. Inst. Phys., Inc., New York, N. Y.)

The purpose of this paper is to present an empirical interpolation between Knudsen's free molecule results and Hagen-Poiseuille flow. The interpolation formula is developed by assuming that the number density is the sum of two terms: the classical isotropic part and an anisotropic correction term. The correction term is so chosen that it is largest near the center of the tube and is zero at the wall. This is equivalent to assuming that only diffuse reflection is allowed at the walls. It is also assumed that the anisotropic part of the number distribution contributes most strongly in the flow direction; and correctly vanishes as the mean free path increases without limit.

While the calculated values based upon the suggested interpolation are in better agreement with experiment than the earlier results, there seems to be much work that could be done along these lines. The significant contribution is the attempt to allow for the presence of the walls, without using the full Maxwell-Boltzmann equation. E. E. Covert, USA

4605. Laurmann, J. A., The free molecule probe and its use for the study of leading edge flows, *Physics of Fluids* **1,** 6, 469–477, Nov./Dec. 1958.

The development of a free molecule probe for use as an instrument in the investigation of two-dimensional rarefied gas flow fields is described. The probe consists of a cross-stream cylindrical wire of diameter small compared with the mean free path of the gas. Measurement of the probe temperature and heat-transfer characteristics yields information that can be related theoretically to the state of the flowing gas. This paper describes the use of such information in the study of the qualitative nature of supersonic flow about sharp leading edges in regions where rarefaction, slip, and boundary layer-shock wave interaction effects are important. The results show clearly the effect of increasing density. Thus, at the lowest densities and Mach numbers, a clearly defined shock wave and boundary layer emerged from a region of mixed compressive and viscous action at the leading edge, while at the higher densities and Mach numbers there was a large region of strong boundary layer-shock wave interaction and a considerable delay in the formation of clearly defined shock wave.

From author's summary by W. P. Jones, England

4606. Trommsdorff, W., Experiments at supersonic velocity on a multi-shock diffuser of simple construction (in German), *Dtsch. Versuchsanstalt Luftfahrt Rep.* 44, 49 pp., Sept. 1957.

Paper presents general discussion of the performance of inlet diffusers with small wave drag and low manufacturing cost. Two similar diffusers of design Mach number 2.6 and each consisting of a sharp-edged cylindrical tube with an axially movable conical center body were tested at Mach numbers 1.94 and 2.21 in the Aachen free-jet blow-down tunnel. The diffuser mass flow was varied by means of an adjustable outlet nozzle, and the angle of yaw was varied from 0° to 8°. Results included are pressure recovery measurements and schlieren and shadow photographs. Special attention was given to the buzzing phenomena.

N. H. Johannesen, England

4607. McGarry, J. B., The development of a variable Mach-number effuser, *Aero. Res. Counc. Lond. Rep. Mem.* 3097, 9 pp. + 11 figs., 1958.

A series of tests was undertaken on a simple, two-dimensional, variable Mach number effuser, or nozzle, designed for the range of supersonic flows up to Mach number 3.0. The performance of the nozzle was assessed from the magnitude of the percentage variation in its exit Mach number distribution. Studies of the effect on the performance of alterations to the position of the nozzle-block pivots and other geometrical features were made. On the basis of these studies, a final build of nozzle was developed which produced flow of a uniformity sufficient for intake and engine model testing over the Mach number range from 1.5 to 3.0.

From author's summary

4608. Riley, N., Effects of compressibility on a laminar wall, jet, *J. Fluid Mech.* **4,** 6, 615–628, Nov. 1958.

Author extends M. B. Glauert's results on the laminar wall jet [*J. Fluid Mech.* **1,** 625–643, 1956; AMR **10** (1957), Rev. 4068] to situations where the flow is compressible. In the case where viscosity is proportional to temperature, similarity solutions for the velocity profile are found in terms of the incompressible solution and a suitably scaled, temperature-dependent distance from the wall. The energy equation is studied in detail and the effects of viscous heating and of initial and wall heating are investigated for a general Prandtl number. A. F. Pillow, Australia

4609. Manov, M. G., Mean gas flow velocity and gas flow rate in jets of high-vacuum pumps, *Soviet Phys.-Tech. Phys.* **3,** 2, 289–296, Nov. 1958. [Translation of *Zh. Tekh. Fix.* **28,** 2, 316–324, Feb. 1958 by Amer. Inst. Phys., Inc., New York, N. Y.].

Data collected by author on speed velocity (liters/sec.) of high-vacuum pumps, operated with a special fraction of petroleum oil, prove that mean velocities in the jets of the pump are much larger than critical ones calculated according to gas dynamics equations. To define this phenomenon author says that jets in the high-

vacuum pump give supercritical flow rates. He shows that according to data from research by another author, mercury high-vacuum pumps can also give supercritical flow rates.

Author experimented on air flow from low to high vacuum through jets and diaphragms in order to ascertain if gas dynamics equations fail because of the longer free paths of gas molecules in vacuum. In no case did he obtain supercritical flow rates. Instead, experiments on two mercury glass pumps made clear the reasons of the phenomenon. Fog appeared at the walls of the ducts of jets; supercritical flow rates were measured. Author deduces that vapor of mercury or petroleum oil in high-vacuum pumps behaves like damp vapor and not like gas; the liquid drops in jets increase the flow rate. Author concludes that value of heat generated in condensation of drops differs very little from heat dispersed through radiation. Consequently flow rate and vapor flow velocity must be calculated by means of relations valid for mixtures of liquid drops suspended in vapor.

Reviewer believes that the article gives an original explanation of a phenomenon, currently unexplained, but of great interest in field of high vacuum pumps. M. Viparelli, Italy

4610. Gundersen, R., The flow of a compressible fluid with weak entropy changes, *J. Fluid Mech.* **3,** 6, 553–581, Mar. 1958.

The flow equations are solved for both isentropic and non-isentropic perturbations to a given isentropic one-dimensional unsteady flow of an inviscid compressible gas. The given isentropic flow is not necessarily uniform. This theory is briefly described in *C. R. Acad. Sci., Paris* **241,** 15, 925–927, Oct. 1955 [AMR **9** (1956), Rev. 1151].

It is shown for a centered simple wave or a uniform flow that the addition of an entropy perturbation only changes the speed of sound and not the particle velocity. For an arbitrary simple wave this result only holds when $u_0(x, t)$ is a linear function of x. The theory is applied to perturbations on given piston and shock-tube flows. It is also applied to the problem of a shock wave passing along a tube of slowly varying cross section, with results similar to those given by Chester [*Phil. Mag.* **45,** p. 1293, 1954].

The method as stated cannot be applied to steady two-dimensional flow, but an analoguous theory could be developed.

G. M. Lilley, England

4611. Hromas, L., and DeGroff, H., Experimental search for the effect of compressibility in unsteady Couette flow, *J. Fluid Mech.* **5,** 1, 140–150, Jan. 1959.

Description is given of an experiment designed to verify the transverse velocity component caused by dilatation of a compressible fluid due to viscous dissipation in unsteady, longitudinal shear flow. Air streaming in axial direction through an annulus between a fixed inner cylinder and a rotating outer cylinder with superimposed oscillations was subjected to an artificial radial temperature gradient. The cylinder oscillations resulted in small temperature fluctuations of the same frequency, measured by a hot-wire anemometer used as resistance thermometer. Authors present a system of flow equations by which they compute the transverse velocity from the observed temperature fluctuation.

This analysis is unconvincing to this reviewer. Though the effect under investigation is a secondary one (dilation), authors did not demonstrate that their omission of the dilatational term in the Navier-Stokes equation is justified; the coupling effects discussed by the authors are, in reviewer's opinion, better suited for analysis by the methods of irreversible thermodynamics.

E. F. Lype, USA

4612. Ting, L., Some integrated properties of solutions of the wave equation with non-planar boundaries, *Quart. Appl. Math.* **16,** 4, 373–384, Jan. 1959.

Integrated properties of solutions of the wave equation with nonplanar boundaries are found and applied to three-dimensional supersonic flow problems and two-dimensional diffraction problem.

These integral relations are useful in the evaluation of total lift and drag of wing-body combination when the linear dimensions of the cross section of the body are not small as compared to the chord length.

For the diffraction of a pulse or a weak shock over a rectangular notch, a pressure integral theorem is obtained.

From author's summary by S. I. Pai, USA

4613. Warren, C. H. E., and Young, A. D., Some proposals regarding the definitions of terms relating to various flow regimes of a gas, *Aero. Res. Counc. Lond. Curr. Pap.* 368, 6 pp. + 1 fig., 1958.

4614. Donibrovskii, G. A., Methods of approximate solution of two-dimensional problems on steady motions of a gas (in Russian), Trudí 3-go Vses. Matem. S'ezda. Vol. 1, Moscow, Akad. Nauk SSSR 1956, p. 203; *Ref. Zh. Mekh.* no. 11, 1957, Rev. 12512.

As in the case of Chaplygin's approximate method, the problem of the motion of gas merges with the marginal problems of the theory of the functions of a complete variable. Here the connection between the pressure ρ and density corresponding to the approximate equations is obtained closer to the adiabatic than by Chaplygin's method. The method recommended is applicable to a number of problems in gas dynamics.

From author's summary
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Boundary Layer

(See also Revs. 4556, 4560, 4595, 4669, 4707, 4735)

4615. Goddard, F. E., Jr., Effect of uniformly distributed roughness on turbulent skin-friction drag at supersonic speeds, *J. Aero/Space Sci.* **26,** 1, 1–15, 24, Jan. 1959.

Experiments were made at Mach numbers up to 4.5. For measurement of skin-friction drag, bodies of revolution with ogival nose and cylindrical afterbody were used, with trip wire at nose to ensure turbulent boundary layer. Cylindrical afterbody was wrapped with commercial sandpaper to form rough surface, and drags of base and ogival nose were subtracted from total drag to find skin-friction drag of cylindrical afterbody. Calculations were made of additional length of surface upstream of cylinder, which would give observed boundary-layer thickness on the cylinder. All Reynolds numbers were expressed in terms of length increased by this addition, and measured drags were increased by calculated drag of additional length.

For roughness heights large enough for quadratic resistance law to hold, effect of compressibility on skin friction is entirely due to reduction of density at wall as Mach number increases. Thus at given Mach number, ratio of C_F to incompressible value is equal to ratio of density at wall to that in free stream. On smooth surface this density effect on skin friction is partly offset by viscosity effects, so that decrease in skin friction with increasing Mach number is greater for rough surface than for smooth.

Critical roughness height k_c, below which surface is hydraulically smooth, appears from these experiments to correspond to $U^* k/\nu \approx 10$ for *any* Mach number up to 4.5.

Measurements of velocity profile showed that change of (U/U^*) due to roughness was a function only of $U^* k/\nu$ and followed the same law as for incompressible flow.

W. A. Mair, England

4616. Hurley, D. G., and Ruglen, N., The use of boundary layer control to establish free streamline flows, being an introduction to the free streamline flap, *Aero. Res. Lab. Melbourne, Austral., Rep.* A.109, 70 pp., Apr. 1958.

Flap consists of part of airfoil's upper surface, hinged at rear, deflecting upwards; *free streamline* leaves airfoil leading edge and (with boundary layer control by slot blowing) attaches to flap nose. Potential-flow theory was reviewed in AMR **11** (1958), Rev. 1250; present paper describes wind-tunnel pressure-plotting experiments on one particular configuration in two-dimensional flow. Application envisaged is to thin wings of high-speed aircraft in low-speed flight, after three-dimensional and swept-wing effects have been investigated. Interesting unexpected observation was regular audio note when boundary layer control was applied.

R. C. Pankhurst, England

4617. Bromberg, R., and Lipkis, R. P., Heat transfer in boundary layers with chemical reactions due to mass addition, *Jet Propulsion* **28,** 10, 668–674, Oct. 1958.

Due to its significance in the rocket field, the flow of chemically reacting gas mixtures is receiving considerable attention. This paper presents a development of the general equations governing the heat transfer through a laminar, compressible boundary layer to a flat plate. The reactions considered involve gases injected through or sublimed from the bounding surface and those contained in the main flow.

Basic assumptions include unity Lewis number, "frozen" mixture thermal conductivity and specific heat, and a Stanton number approximating the nonreacting value. Final results indicate that the heat transferred equals the nonreacting value, involving only species at the boundary-layer edge, plus terms containing heats of reaction and specie concentrations at the wall.

A numerical evaluation generally requires a wall concentration determination by a simultaneous satisfaction of the applicable energy, momentum, continuity, and reaction-rate equations. It is shown, however, that if an irreversible reaction goes to completion the heat transferred is independent of these wall concentrations.

H. E. Brandmaier, USA

4618. Cohen, C. B., Bromberg, R., and Lipkis, R. P., Boundary layers with chemical reactions due to mass addition, *Jet Propulsion* **28,** 10, 659–668, Oct. 1958.

The general equations of the preceding review are further restricted to unity "frozen" Prandtl number, zero axial pressure gradient, and infinite chemical reaction rates. The last assumption permits the approximation that these reactions only occur in discrete planes parallel to the flat plate.

The applicable continuity, momentum, and energy equations are solved for the required wall concentrations of the reacting species. Results of the examples presented indicate that:

1. For irreversible reactions the heat transferred to the surface differs from the nonreacting case by an amount proportional to the heat of reaction and is independent of the reaction plane location.
2. For irreversible, temperature-limited reactions in which the injection rate is less than a critical value, the heat transfer is reduced from that in the above case by an amount dependent on the reaction plane location.
3. For reversible reactions in which recombination occurs before the reaction products reach the wall, there is no effect on heat transfer.

Reviewer's only technical comment is to concur with authors that the effect of chemical reaction on departures of the Lewis and Prandtl numbers from the assumed values of unity should be studied. As the subject material of the present paper and that of the preceding review are identical, it is reviewer's opinion that their combination into a single paper would have increased the clarity and impact of the presentation.

H. E. Brandmaier, USA

4619. Rosner, D. E., Boundary conditions for the flow of a multicomponent gas, *Jet Propulsion* **28,** 8, 555–556 (Tech. Notes), Aug. 1958.

Effects of surface reactions of catalytic or combustion type on boundary conditions for boundary-layer flows are considered. Equations are formulated for the rate at which each chemical specie i of an N-component gas is consumed or produced by interaction with a surface. In addition to a coupling between the differential equations governing velocity, composition, and temperature fields there is also a complicated coupling between chemical kinetic and hydrodynamic boundary conditions at surfaces where reactions occur. Solutions can be obtained only by iterative techniques. For pure steady-state surface catalysis these conditions uncouple, and the hydrodynamic condition at the wall may be specified *a priori*.

G. L. Dugger, USA

4620. Jarre, G., The dissociation of a pure diatomic gas in a laminar boundary layer on an adiabatic flat plate, AFOSR TN 58-944 (Lab. Meccanica Applicata Politecn. Torino TN 10; ASTIA AD 205 082), 16 pp. + 2 figs., Sept. 1958.

Problem treated is that of cold free-stream impinging on insulated semi-infinite flat-plate. Total enthalpy of stream is sufficiently high to cause partial dissociation in boundary layer. Finite dissociation rate is used, and approach to equilibrium studied. Problem has also been considered by Broadwell [*J. Fluid Mech.* **4,** 113–139, June 1958] using different method, but results do not appear to be directly comparable. Equation of state of perfect gas, constant specific heat, and Prandtl and Lewis numbers of one are used. Viscosity coefficient does not enter result. Reaction rate expression is one derived by author in previous report. Two simple techniques lead to almost identical asymptotic expressions for degree of dissociation and temperature at wall in terms of distance from leading edge. For free-stream temperature of 300 K, pressure of 10^{-4} atm, $M = 15$, wall-temperature parameter reaches 99% of equilibrium value in 7.8 meters for O_2, in 39 meters for N_2.

L. Mack, USA

4621. Savulescu, St., Considerations on some solutions for the unsteady compressible boundary layer (in Roumanian), *Studii si Cercetari Mecan. Appl.* **9,** 4, 867–879, 1958.

Paper extends an idea previously presented by the author [AMR **11** (1958), Rev. 4731] to use typical temperature and velocity profiles for studying two-dimensional and axisymmetric unsteady boundary layers. This method is applied to motions whose exterior flow conditions (velocity and temperature of the exterior flow and wall temperature) are such that solutions of the Crocco type may be obtained, i.e., identity between velocity and energy profiles, under a dimensionless form. The conditions of the exterior flow are deduced under the form of partial differential equations for the exterior flow velocity and wall temperature. Formulas for the friction coefficient and heat transfer are determined for motions having the Prandtl number equal to unity. Applications are included for various flows (flat plate in braked supersonic flow, etc.) and the differences with respect to the corresponding steady case are pointed out.

V. N. Constantinescu, Roumania

Turbulence

(See also Rev. 4564)

4622. Fidman, B. A., On energy balance in turbulent flow with separation from the boundary (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 8, 139–142, 1958.

Fidman investigates the energy balance in turbulent flow with separation from the wall. The medium in question is water and the separation was achieved by a step in the bottom of the top-opened channel, in which the motion takes place. The Reynolds number of the flow was equal to 14,500 and the flow pattern was measured by means of movie camera. The mean velocity of motion was 29 cm/sec. Author provides diagrams showing the distribution of the horizontal and vertical mean-square-root velocity components. Next, the author, using the known relation $V = \overline{V} + V'$, decomposes the complete energy in the turbulent flow into some parts: transfer of energy by convection, turbulent diffusion, production of the pulsation kinetic energy, dissipation, etc. Each of these partial energies is decomposed into two directions: horizontal and vertical. The graphs show that the production of the pulsation kinetic energy in the horizontal direction is 10 times greater than in the vertical direction. Hence the concept of an isotropic homogeneous turbulence cannot be applied. Concerning the transfer of the pulsation energy from the kinetic form into the potential form (and vice versa), the relation is $0_x = -2 \cdot 0_y$.

M. Z. Krzywoblocki, USA

4623. Napolitano, L. G., High speed machine solutions for plane turbulent homogeneous and nonhomogeneous mixing; Two-dimensional plane mixing of homogeneous and nonhomogeneous streams, Polyt. Inst. Brooklyn, Aero. Lab. Rep. no. 399, 37 pp., Oct. 1957; Rep. no. 400, 29 pp. + 17 figs., Nov. 1957.

While waiting for accurate experimental knowledge concerning the nature of turbulence, theorists have been making analytical and numerical calculations in order to find the results of suppositions which may, however, be too simple but which make calculations possible. If the results of the calculations turn out to agree with future experiments, then the suppositions in question are supported.

Such a problem is the calculation of mean values for the velocity and density in the mixing layer between two semi-infinite gas streams. To simplify the problem, the gases are supposed to be ideal, the pressure constant, and so on. Napolitano has investigated the differential equations for the mean motion and has put them into a form fit for calculations. He has integrated them using a high-speed computing machine and given the results in 29 tables. Finally, he has published a simplified method which can be employed without requiring access to high-speed machines. This method does not give exactly the same results as those obtained using the high-speed machine. Napolitano states that only experimental data can decide which of the two methods is the better one. He considered, in the first place, the mixing layer between two streams of the same gas, but the streams may also consist of different gases, under the condition that certain assumptions hold true.

As is seen from figures 2 d, e, f, & g, the density varies considerably and in a surprising manner. The reviewer also wishes to query Napolitano's putting Prandtl and Schmidt numbers equal to one, etc.

Another interesting finding is that, in all cases for which the density ratio can be expressed as a parabolic function of the velocity ratio, turbulent velocity profiles are substantially independent of the nature of the gases, the enthalpy ratio and the Mach numbers.

H. O. Faxen, Sweden

4624. Ferrari, C., Wall turbulence (in Italian), Monogr. Lab. Aero. Politecn. Torino no. 417, 116 pp., Sept. 1957.

In these lectures, given at the Center of Varenna, author presents the theoretical aspects of the wall turbulence.

After an introductory chapter on the general equations for the mean velocity and the correlations at a single point, the two-dimensional channel flow is treated in detail in chapter 2. The boundary layer without pressure gradient (including heat transfer and the case of compressible flow) is studied in chapter 3. The fourth chapter deals with the boundary layer in a pressure gradient. The last chapter gives a summary of the theoretical approaches of Burgers and Malkus.

The basic notions around which the material is organized are the distinction of an inner and outer region, and the use for the latter of the Boussinesq eddy viscosity coefficient, taken constant within each cross section but varying along the flow.

Research workers and students in the field who will read carefully this clearly written, logically organized monograph, will specially appreciate its thorough discussion of the working hypothesis involved.

A. J. Craya, France

Aerodynamics

(See also Revs. 4313, 4569, 4575, 4576, 4584, 4666, 4670, 4671, 4672, 4742, 4743)

4625. Peckham, D., The geometry of wing surfaces generated by straight lines and with a high rate of thickness taper at the root, *Aero. Res. Counc. Lond. Curr. Pap.* 383, 11 pp. + 12 figs., 1958.

It is desirable if wings can be designed so that the surfaces are generated by straight lines. This note describes and gives mathematical expressions for wings generated by straight lines parallel to the leading and/or trailing edges. The method can be most successfully applied to wings of parabolic arc section straight-tapered in planform, in which case there is no change in airfoil section shape across the span. In this case there are two sets of straight generators. The thickness taper decreases from the root to the tip, which is desirable from both aerodynamical and structural points of view. Other planform shapes, and wing-root airfoil section shapes, result in a variation of airfoil section shape across the span.

T. Gullstrand, Sweden

4626. Neumark, S., Collingbourne, J., and York, E. J., Velocity distribution on thin tapered arrowhead and delta wings with spanwise constant thickness ratio at zero incidence, *Aero. Res. Counc. Lond. Rep. Mem.* 3008, 37 pp., 1958.

This report is the fifth of a series [for previous reports see AMR **6** (1953), Rev. 1691; AMR **7** (1954), Rev. 1864; AMR **8** (1955), Revs. 163 and 1098].

The first-order method of linear perturbation is used to determine the velocity distribution on a family of straight tapered sweptback wings of biconvex parabolic profile. The fundamental formulas are given and particular attention is paid to the singular integrals which occur. These are reduced to a form suitable for automatic computation.

Tabulated results are given for affinely related wings (of varying sweepback, taper and aspect ratio) of two main types (1) wings of moderate and large sweep and (2) delta wings. Isobar patterns are given for 36 of these wings (of extreme taper ratios 1/16 and 7/16). For the sweptback wings the maximum supervelocity is insensitive to taper ratio (in given range) and occurs on the root section for wings with considerable sweepback (for the given wing section). For the delta wings the maximum supervelocity occurs on the outboard part of the span.

Using Gothert's affine transformation, the velocity distribution over these wings at certain subsonic Mach numbers can be found by relating the given wing to another member of the family in incompressible flow. Thus lower critical Mach numbers can be readily obtained (for the given wing section).

A. W. Babister, Scotland

4627. Keldysh, V. V., Application of slender-body theory to the calculation of aerodynamic properties of low aspect ratio wings with nacelles at their tips, *J. Appl. Math. Mech. (Prikl. Mat.*

Mekh.) **22,** 1, 172–181, 1958. (Reprint order no. PMM 12, Pergamon Press, 122 E. 55th St., New York, 22, N. Y.)

The nacelles in the title are bodies of revolution, which may be ducted; the trailing edge of the wing is straight and coplanar with the bases of the nacelles.

Details of the appropriate conformal mapping are given, and the final results for the velocity potentials and aerodynamic coefficients are stated without derivation. Most of the paper consists of tabular and graphical presentation of numerical results, and discussion of these. G. N. Ward, England

4628. Syvertson, C. A., and Dennis, D. H., A second-order shock-expansion method applicable to bodies of revolution near zero lift, *NACA Rep.* 1328, 18 pp. + 2 tables, 1957.

See AMR **9** (1956), Rev. 2606.

4629. Gersten, K., Nonlinear lifting-surface theory for rectangular wings in incompressible flow (in German), *Z. Flugwiss.* **5,** 9, 276–280, Sept. 1957.

Bollay [*ZAMM* **19,** 21–35, 1939] proposed a wing theory for small aspect ratio in which trailing vortices emanating from the side edges of a rectangular wing extended downstream at a constant inclination of half the wing incidence α. Here Bollay's model is modified so that a trailing vortex extends downstream at the Bollay angle ($\alpha/2$) from each point of the planform. Next, the planform is divided into n strips of chord c/n, where c is the wing chord. The bound-vortex distribution of each strip is replaced by a bound line-vortex at its ¼-chord line, and it is proposed to satisfy the boundary condition of tangential flow at the wing only at the ¾-chord line of each strip. This results in a theory similar to various proposed lifting-surface theories in the linear range but differing by the fact that the significant spanwise lines do not lie in the trailing-vortex sheets. The calculations of the influence coefficients of the several bound vortices at the several ¾-lines are made approximately for small α; finally, terms of order α and α^2 appear in the lift and moment, and α^2 and α^3 in the drag.

As a numerical example, a calculation is carried out for $n = 3$ and with each of the three bound-vortex distributions represented by the sum of α and α^2 terms in sin θ, sin 3θ, and sin 5θ, where θ is the customary angular spanwise coordinate. Comparison with various experimental data on flat rectangular wings of aspect ratio 0.2, 0.5, 1.0, and 5.0 is carried out and very encouraging agreement is shown. W. R. Sears, USA

4630. Dickey, R. R., The effect of moment-of-area-rule modifications on the drag, lift, and pitching-moment characteristics of an unswept aspect-ratio-6 wing and body combination, *NASA Memo* 2-24-59A, 29 pp. Mar. 1959.

The lift, drag, and pitching moments of models modified according to the moment-of-area rule were measured and compared with those of the unmodified configuration at Mach numbers from 0.6 to 1.4 and at angles of attack from $-2°$ to $+12°$. The models had an unswept aspect-ratio-6 wing that was 6 percent thick.

From author's summary

4631. Powell, R. D., Jr., Maximum mean lift coefficient characteristics at low tip Mach numbers of a hovering helicopter rotor having an NACA 64$_1$A012 airfoil section, *NASA Memo* 1-23-59L, 25 pp., Feb. 1959.

The investigation was conducted on the Langley helicopter test tower with a helicopter rotor having an NACA 64$_1$A012 airfoil section, a constant chord, and 8° of linear washout. Data are presented for tip Mach numbers ranging from 0.29 to 0.74 (corresponding blade tip Reynolds numbers ranging from 2.59×10^6 to 6.58×10^6) and are compared with two-dimensional data as well as with other rotor experimental data. Synthesized section lift and profile-drag characteristics for the NACA 64$_1$A012 airfoil as a function of angle of attack and Mach number are presented for use in helicopter-rotor performance calculations.

From author's summary

4632. Leist, K., and Dettmering, W., Testing of facilities for the measurement of the pressure distribution in rotating blades (in German), *Dtsch. Versuchsanstalt Luftfahrt Ber.* 56, 83 pp., June 1958.

4633. Laitone, E. V., Dynamic longitudinal stability equations for the re-entry ballistic missile, *J. Aero/Space Sci.* **26,** 2, 94–98, Feb. 1959.

Paper deals with problem of the effects on dynamic longitudinal stability of accelerations or decelerations of a ballistic missile. Equations of motion are developed by two methods; first, the procedure involving small perturbations in the flight trajectory equations. The second method utilizes Euler's equations for body axes.

There is an extended discussion of the approximations involved in the usual application of these methods, of particular significance being the limitation of hypersonic speeds and high drag (blunted) bodies. Applications are made to several special cases. M. J. Thompson, USA

4634. Watts, M. R., and Fry, D. E., The longitudinal response of an aircraft with auto-pilot, including an incidence term in the height control equation, *Aero. Res. Counc. Lond. Curr. Pap.* 396, 15 pp. + 1 table + 11 figs., 1958.

This paper gives the results of a theoretical investigation into the dynamic stability of an aircraft under automatic height control. Inaccuracies in the barometric height information due to incidence changes are shown to be destabilizing. Either the short-period or long-period motion may lose damping depending on the sign of the static pressure error. From authors' summary

4635. Walton, R. P., and Campbell, L. G., Jr., Bringing the helicopter under control, *Control Engng.* **6,** 1, 71–76, Jan. 1959.

Paper illustrates application of servomechanism theory to helicopter control. Forward transfer functions for longitudinal freedoms pitch, translation, rotor altitude are built up by stages and illustrated by root-locus and frequency-response plots. Simple feedback loops suitable for controlling pitch and translation are developed. A. D. Young, England

4636. Theodorides, P., Investigation of factors affecting the control and stability of high speed aircraft and missiles, AFOSR TR 58 52 (Inst. Fluid Dynam. Appl. Math., Univ. Maryland, TN BN-129; ASTIA AD 154 215), 12 pp., Apr. 1958.

After a brief introduction, the work is reviewed under the headings: (a) Basic theory in fluid dynamics; (b) Aerodynamics of unsteady flow; (c) Elasticity of high-speed wings; (d) Shock analysis in nonmonatomic media.

A listing is given in chronological order of the Reports and Publications bearing on the contract work, accompanied by abridged abstracts.

A last chapter deals with significant findings in shock analysis.

From author's summary

4637. Schueller, C. F., Inlet-engine matching and control systems for supersonic airplanes (in English), C. R. Journées Internationales de Sciences Aéronautiques, Paris, May 27–29, 1957; Part I, 27–41. O.N.E.R.A.

4638. Eggleston, J. M., and Diederich, F. W., Theoretical calculation of the power spectra of the rolling and yawing moments on a wing in random turbulence, *NACA Rep.* 1321, 19 pp., 1957.

See AMR **10** (1957), Rev. 1556.

4639. Engel, J. N., and Copp, M. R., Analysis of acceleration, airspeed, and gust-velocity data from a four-engine transport airplane operating over a northwestern United States-Alaska route, *NASA Memo* 1-17-59L, 15 pp., Feb. 1959.

The data, which were obtained with an NACA VGH recorder, were evaluated and then compared with the results previously reported in *NACA TN* 3475 for two similar airplanes operating over transcontinental routes in the United States. No large variations in gust experience were noted for the three operations. In general, accelerations due to gusts occurred much more frequently than those due to operational maneuvers.

From authors' summary

4640. Brun, E. A., editor, Icing problems and recommended solutions (in French and English), *AGARDograph* 16, 264 pp., Nov. 1957.

Various aspects of aircraft icing problems are discussed by authors from different NATO countries, and the whole text is in both English and French. Chapter headings are: 1. General survey; 2. Icing conditions to be considered in the design of protection systems; 3. The measurement of icing conditions; 4. Icing wind tunnel tests; 5. Flight tests in simulated icing conditions; 6. Icing flight test concepts in the U. S. A.

Papers were presented at the Flight Test Techniques and Instrumentation Panel of AGARD in July 1956. Amendments up to November 1957 are included.

From author's summary by M. Tribus, USA

Vibration and Wave Motion in Fluids

4641. Yamada, H., On approximate expressions of solitary wave, *Rep. Res. Inst. Appl. Mech. Kyushu Univ.* **6,** 21, 35–47, 1958.

The method, given by the author in AMR **11** (1958), Revs. 1269, 1270, is essentially the method of Levi-Civita [*Math. Ann.* **93,** p. 264, 1925] adapted to numerical iterative solution. In the present paper, author uses this method to evaluate the solution for two waves, with height-to-depth ratios of 0.8284 and 0.4808. A graphical comparison is given with the well-known results of Boussinesq, Rayleigh and McCowan, as well as with the recent work of Packham [*Proc. Roy. Soc.* (*A*) **213,** p. 238, 1952]. Of these, Boussinesq's results agree closely with the author's, and Packham's are not greatly different. The experiments of Daily and Stephens [*Coastal Engng.* **3,** div. 2, chap. 2, 1952] showed a solitary wave of permanent type, the characteristics of which agree closely with the author's and with Boussinesq's theory.

J. M. Jackson, Scotland

4642. Smirnov, G. N., and Sidorova, A. G., Changes in the parameters of a wave during its progress above a sloping bottom (sea bed) (in Russian), *Sb. Trudï Mosk. Inzh.-stroit. Inta* no. 20, 103–113, 1957; *Ref. Zh. Mekh.*, no. 3, 1958, Rev. 2915.

After a detailed rechecking of the empirical and approximate formulas recording the relationships of the changes of the height of the wave when reaching shoal water, authors describe the experimental verification of the formulas. To conclude, a series of deductions is given. In particular, it is asserted that the result most closely approximating the corresponding experiment is obtained by using Yu. M. Krylov's formula. The formulas advanced by Bozhich, Geier and Erie give results far removed from the observed. Authors also note that even for a sea bed where the slope is not markedly large, the repulsion can not be disregarded.

N. N. Moiseev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4643. Lappo, D. D., Problem of the determination of the depth of destruction of waves in shallow waters (in Russian), *Trudï Dal'nevost. Politekhn. In-ta* no. 45, 27–41, 1956; *Ref. Zh. Mekh.* no. 10, 1957, Rev. 11612.

The development is investigated of a steady wave system in a water basin of variable depth. Assuming that there is no wind and that the loss of energy is insignificant (or that the energy brought in by the wind is approximately equal to the energy lost) the equation of the equilibrium of energy can be presented in the form

$$\frac{\partial}{\partial x}\left(\frac{\gamma h^2}{8}u\right) = 0 \quad \text{or} \quad \frac{\gamma h^2}{8}u = \text{const}$$

when h is the height of the wave, measured vertically from the crest to the trough, u is the group speed of the waves, γ is the weight by volume of the water, x is the distance along the direction of motion of the wave. The indicated integral serves in the investigation of the wave transformation when it reaches shallow water. In this case the wave changes its parameters in relation to the depth of the water basin, which is represented by the graph $H = f(\lambda, \tau)$ ($0 \leqslant H \leqslant 25$m is the depth of the water basin; 4 sec $\leqslant \tau \leqslant$ 15 sec is the wave period; $0 \leqslant \lambda \leqslant 150$ m is the length of the wave) and by the correlation $h = \theta h_0$ (θ is the coefficient of the transformation of the height of the wave when the water basin's depth is $H \geqslant \frac{1}{2}\lambda$).

For θ, a universal function is proposed: $\theta = F(\lambda/\tau^2)$ when $0 \leqslant \lambda/\tau^2 \leqslant 1.56$, but separate functions for the case of gradually decreasing or sharply decreasing depths of the water basin. Author uses the results for the determination of the critical depth H_{cr} for the destruction of the waves at given wave parameters h, τ and λ. It is assumed that $H_{cr} = 1.5h_H$ (h_H is the depth of the water basin, equal to the height of the wave at a given λ). To simplify the calculations for H_{cr} determinations, a nomogram was constructed to cover the more frequently met-with in practice, in marine hydrotechnical engineering, initial conditions—the parameters of the wave in deep water and the water depths in the offshore zone. The nomogram is put forward as being more soundly founded than that recommended in GOST-3256-46 as a means of determining H_{cr}.

S. V. Nemchinov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4644. Ivanova, L. S., Impact of a liquid on the inclined wall of an infinite, partly closed container, *J. Appl. Math. Mech.* (*Prikl. Math. Mekh.*) **22,** 2, 344–348, 1958. (Reprint order no. PMM 29, Pergamon Press, 122 E. 55th St., New York 22, N. Y.)

The pressure distribution on the end wall of a container is mathematically determined for impulsive motion starting from rest. The bottom of the container is infinite. The end wall is inclined. The top is finite in length and parallel to the bottom. An incompressible liquid fills the tank to the top with the free surface extending to infinity and being parallel to the bottom.

With impulsive motion starting from rest the velocity potential is proportional to the pressure. The velocity potential is derived by conformal mapping of the bounding surfaces of the liquid, by satisfying the zero-pressure condition on the free surface and by use of the known normal velocities along the solid boundaries. Pressure distribution is numerically evaluated along the inclined wall angles (from the bottom) of $\pi/4$, $\pi/2$, and $3\pi/4$ and for various lengths of the top.

Although author states that the solution can be applied to the impact of a liquid on an inclined dam or to the impact of a liquid cargo on the bulkhead of a ship, he fails to discuss the effect of shock waves (water hammer) upon the pressure when the motion is instigated impulsively.

M. R. Carstens, USA

4645. Schnitzer, E., Water-impact theory for aircraft equipped with nontrimming hydro-skis mounted on shock struts, *NACA TN* 4256, 25 pp. + 5 figs., Sept. 1958.

Theoretical equations are derived for the motion of aircraft equipped with hydroskis mounted on shock struts during take-off and landing operations on a water surface. The case considered involves a ski which is fixed in trim relative to the aircraft and which translates upward during impact and thus telescopes the shock strut. Two hydrodynamic force relations, one more accurate but more complex than the other, are considered. Incorporation of suitable shock-strut spring and damping approximations along with the simpler hydrodynamic-force term allows the equations to be written in nondimensional form for design-trend studies. Such trend-study solutions have been made for a broad range of practical water impacts and are presented as dimensionless plots. The equations involving the more accurate force term are usable only in the dimensional form as presented, but they allow any spring type, any exponential damping constant, and a variety of ski bottom shapes to be included in the solutions. Thus the trend-study solutions may be used for rough preliminary design and the more accurate solutions for final design. An appendix is included which gives a simple step-by-step procedure for solving any of the sets of equations derived in the paper.

From author's summary by P. Eisenberg, USA

Fluid Machinery

(See also Revs. 4301, 4334, 4475, 4520, 4570, 4631, 4635)

4646. Sherstyuk, A. N., Potential subsonic flow around accelerating and decelerating cascades (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 4, 123–126, Apr. 1957.

Steady plane potential and subsonic flow of ideal gas is considered. Curvilinear coordinates are lengths of stream and potential lines are used in basic equations. The purpose is to obtain an approximate correspondence between the plane of gas flow and the plane of a suitable flow of incompressible fluid in similar manner as Christianovich did [*Trudi CAGI* 481, 1940]. The well-known method of Christianovich consists in replacing Chaplygin's function K by its value K_∞; author introduces two other expressions applicable in the case of single airfoil and cascade of airfoils, respectively, both being higher approximations than that of Christianovich. By the use of formulas given in the paper the subsonic flow of gas around the cascade of airfoils can be easily transformed into the flow of incompressible fluid around the properly distorted cascade of airfoils.

W. Prosnak, Poland

4647. Pavel, D., New methods for the determination of the characteristic data of over pressure (reactive) turbines (in Hungarian), *Hidrológiai Közlöny* **38,** 2, 102–109, Apr. 1958.

4648. Troskolanski, A. T., Fundamental problems of the dynamic similarity of rotodynamic hydraulic machinery (in Polish), *Przeglad Mech.* **17,** 11, 495–501, 1958.

Author develops the theory of dynamic similarity of rotodynamic hydraulic machinery and, using dimensional analysis, derives a dimensionless expression for specific speed, the same for rotors of turbines and impellers of pumps; $n_{sf} = 1000\ n\ Q^{0.5}/60\ (g\ H)^{0.75}$, where n is in rpm. This unique and universal dimensionless number can be applied internationally for normalization and model tests of turbines and pumps. Paper deserves attention.

S. Kolupaila, USA

Book—4649. Lazarkiewicz, Sz., and Troskolanski, A. T., Rotodynamic pumps [Pompy wirowe], Warszawa, Panstwowe Wydawnictwa Techniczne, 1959, 553 pp. + 13 plates. *Zł.*80.

A modern and well-elaborated treatise on impeller pumps, the first of such extent, not only in Polish language; it can be favorably compared with works by H. Addison, C. Pfleiderer, and A. J. Stepanoff. Book covers all types of rotodynamic pumps: centrifugal, screw-type impeller, half-axial and axial-flow impeller types. Contents are very extensive: basic theory of vortex pumps, balance of energy, liquid flow through a rotor, dynamic similarity of pumps, shape of rotors with plain vanes and of double curvature, impeller blades, inlets and outlets, structural elements, pressure and cavitation, characteristics, efficiency regulation, drives, examples of design, self-priming pumps, ejectors, pump and model tests, installation and maintenance. Tables and indices conclude this perfectly edited book.

The text is lucid and can be easily translated with the aid of a multilingual index at the end of the book. State Technical State Publishing House of Poland can be praised for the print and design of very high quality. There can be no doubt that this useful book will be translated into other languages.

S. Kolupaila, USA

4650. Krivoshein, V. F., The method of stage adjustment for axial compressor (in Russian), *Teploenergetika* no. 6, 43–49, June 1958.

Paper describes the method of stage adjustment for axial compressor, i.e. the approximation of actual characteristics to those obtained by calculation. From author's summary

4651. Doomov, V. I., The increase in non-cavitation property of the centrifugal pump stages by means of axial pre-connected impellers (in Russian), *Teploenergetika* no. 4, 16–21, April 1957.

4652. Camposampiero, C., A practical method for designing radial turbines (in Italian), *Aerotecnica* **38,** 5, 253–259, Oct. 1958.

4653. Medici, M., A contribution to the improvement of the three-dimensional flow theory of turbomachines (in Italian), *Ric. Scient.* **28,** 6, 1116–1132, June 1958.

4654. Zavadovsky, A. M., Dependences characterizing flow-passing capacity of the turbine stage (in Russian), *Teploenergetika* no. 4, 6–10, April 1957.

Description is given to the method used for determination of the dependences characterizing flow-passing capacity of the turbine stage. The functional ties between main aerodynamic characteristics of the turbine state are established.

From author's summary

4655. Sokolov, N., The calibration of screw propellers (in Russian), *Mor. Flot.* no. 12, 20–22, 1956; *Ref. Zh. Mekh.*, no. 3, 1958, Rev. 2944.

A method is described for eliminating the statical nonequilibrium of screw propellers, accomplished by eccentric drilling of the bosses during the manufacture of the screws, instead of the usually accepted way of removal of metal from the blade of the screw in nonequilibrium. I. V. Girs

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4656. Ivanov, S. N., Experimental device with reversible screw blades of controllable pitch on the diesel-engined ship "Opyt" (in Russian), *Trudi Tsentr. N.-i. In-ta Morsk. Flota* no. 7, 72–81, 1956; *Ref. Zh. Mekh.*, no. 3, 1958, Rev. 2943.

A description is given of the structural details of an adjustable 3-blade screw propeller of controllable pitch (VR Sh) designed and built by the Central Scientific Research Institute of the Marine Fleet (Ts NIIMF) and suitable for one of the series of tugboats built by the Riga naval yard, with hp of 150; the device was assembled on the floating laboratory of the Ts NIIMF of the D/E ship "Opyt." The turning mechanism of the blades in the boss and the hydraulic gear with two servomotors permits the alteration of the pitch of the blades by an angle of ±30° from the normal.

The whole control of the VR Sh is centered in the confines of the diesel engine. The time taken to change the pitch to its maximum is 8–15 secs. I. V. Girs

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4657. Cheeseman, I. C., A method of calculating the effect of one helicopter rotor upon another, *Aero. Res. Counc. Lond. Curr. Pap.* no. 406, 16 pp., 1958.

A model of the induced flow around a lifting rotor is derived by considering a lifting-line approximation to translational lift and a stream tube model for propeller lift. This theory is applied to a tandem rotor configuration in rectilinear flight. It is shown that the values derived are in good agreement with the available experimental results, which relate the case of no gap or stagger. In this special case the stream tube effect is negligible and only the lifting-line approximation is used.

From author's summary

Flow and Flight Test Techniques and Measurements

(See also Revs., 4553, 4581, 4589, 4592, 4616, 4688, 4803)

Book—4658. Fluid meters—their theory and application, 5th ed., New York, American Society of Mechanical Engineers, 1959, 203 pp. $8.

The fact of a fifth edition in 35 years is the best recommendation for this widely known book dedicated to measurement of liquids and gases. Credit for this edition belongs to H. S. Bean, chairman of a special subcommittee. Contents are similar to previous editions: classification and nomenclature, quantity meters, rate meters, area meters, head-area meters, force and velocity meters, thermal meters, special methods, conversion factors, tables and diagrams. Important improvement in this edition is the gravitational system of units and the Reynolds number as an argument for the discharge coefficients. A revised list of references includes many new papers. Regrettably too many errors in foreign titles spoil this well-edited and printed volume. S. Kolupaila, USA

4659. Kronmuller, H., Flow measuring of gases of varying working densities (in German), *Regelungstech.* **6,** 11, 391–395, 1958.

It is the general practice in process plants to use orifices and nozzles for checking and controlling the flow of gases to the various consumers. An approximate value for the flow is then calculated on the basis of the average day values of the operating pressure, the working conditions and the normal densities of the flowing gases. In this article the principal faults of this procedure are shown and the ensuing divergencies from the true flow value are estimated from different points of view.

Continuous-flow-computing systems have none of these faults. One such method, which works with a force-balance measuring transmitter and a simple analog computer without moving parts, is described. From author's summary

4660. Hastings, R. C., A note on the interpretation of base pressure measurements in supersonic flows, *Aero. Res. Counc. Lond. Curr. Pap.* 409, 13 pp. + 6 figs., 1958.

Empirical theory and experimental methods are reviewed in the light of the existing knowledge of the flow behind the blunt base of a body in a supersonic flow.

A discussion of the interpretation of small-scale experiments with natural transition from laminar to turbulent boundary-layer flow shows that some difficulty may be encountered in deriving these from the base drag at the high Reynolds numbers of practical interest. While tests with artificial transition, which include boundary-layer measurements, may help to overcome this difficulty, investigations at large scale may also be required. Increase of high Reynolds number is thought to raise base drag appreciably at Mach numbers less than 2.

Although none of the empirical methods of estimating base drag is entirely satisfactory, one due to Love is recommended provisionally. The inclusion of jet effects, which are not otherwise considered in the present Note, influences this choice.

From author's summary

4661. Westley, R., An investigation of the frequency response of pitot probes and preliminary measurements of the pitot pressure fluctuations in the N. A. E. 5-in. Pilot Supersonic Wind Tunnel, *Nat. Aero. Establ., Canada, Lab. Rep.* LR 214, 6 pp. + 16 figs., Dec. 1957.

The frequency response characteristics of pitot probes were investigated with a view to the use of probes for the measurement of the pitot head fluctuations in a high-speed wind tunnel. A sound source method was used to calibrate the responses of four pitot probes and a hypodermic boundary-layer probe. The useful frequency range of a probe was found to decrease markedly with increase of the length of tube between the probe inlet and the pressure transducer.

Preliminary measurements were made of the spectra of the pitot head pressure fluctuations in the contraction entry and working section of the N. A. E. 5-in. Pilot Wind Tunnel for a Mach number of 1.2. From author's summary

4662. Redding, T. H., Alternative presentations of pressure-inferential metering formulae. Parts I, II, *Engineer, Lond.* **207,** 5374, 133–136, Jan. 1959; **207,** 5375, 173–178, Jan. 1959.

The author sets out to present the usual metering formulas for pressure-inferential-type flow meters (orifice nozzle, etc.) in more convenient forms for direct solution in terms of discharge or pressure difference.

An exhausting dimensional study is made, setting down the usual orifice variables with all fluid properties assumed significant. The suitability of various forms is discussed at length, and numerous modifications and simplifications are made to these formulas in the light of experimental evaluations. For compressible flow some of the curves appear to have some real advantage in establishing meter performance without trial and error calculation.

Reviewer finds paper excessively elaborate, not particularly lucid in presenting clearly the significant physical variables but useful in allowing ready computation. Simpler presentation would give the potential user greater (and quicker) confidence in their use. R. Culver, Australia

4663. Pryadilov, A. I., Piezo-electrical pressure indicator for the investigation of the frequency and character of the pulsations of a flow of air in a turbo-engine (in Russian), *Energomashinostroenie* no. 12, 22–24, 1956; *Ref. Zh. Mekh.* no. 3, 1958, Rev. 3111.

A description is given of a piezo-electrical pressure indicator used to measure the pressure of the pulsations in the sections of the compressor and turbine between the inlet and outlet valves through which steam passes. Potassium sodium tartrate (Rochelle salt) is used which, at the normal moisture content of the flow and a turbulence temperature of 40 to 45°, permits the measurement of the frequency of vibrations up to 5000 Hertz. The amplification of the electrical impulses emerging from the trans-

mitter was effected by means of a wide strip amplifier. The recording of the impulses was done on a cathode-ray oscillograph.

I. S. Simonov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4664. Pathak, P. D., and Patel, R. M., A compact instrument for the measurement of surface tension of liquids, *Indian J. Phys.* **32,** 10, 464–467, Oct. 1958.

An instrument for the measurement of surface tension of liquids by a null method is described. The method of balancing the downward force of surface tension on the edge of a thin glass plate by the upward hydrostatic pressure of the liquid is used. The instrument is quite compact, handy and sensitive, and can be used for rapid measurement on a number of samples.

From authors' summary

4665. Bagrov, A. A., The measurement of viscoplastic constant dispersion systems with the aid of a rotating viscosimeter (in Russian), Uch. Zap. Rostovsk. N/D Gos. Ped. In-ta. Yubileinyi Sb. (K. 25-Letiyu In-ta), 1955, 308–315; *Ref. Zh. Mekh.* no. 3, 1958, Rev. 3121.

For the readings of the rotating viscosimeter a squared-paper nomogram is drawn, which makes it possible to find the relation of the angular velocity of the rotating cylinder, at which the flow takes in all the layers of the viscoplastic system under investigation, to the relation η_{pl}/θ and r/r_0, where η_{pl} is the plastic viscosity in the Shvedov-Bingham equation, θ is the boundary shear stress, r and r_0 are the radii of the outer and inner cylinders of the viscosimeter. The practicability of the application of the nomogram for the investigation of the viscoplastic properties of materials is demonstrated by examples with peat.

N. I. Malinin

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4666. Butler, S. F. J., Low-speed wind-tunnel tests of the effects of various leading-edge modifications on the sectional characteristics of a thin wing, *Aero. Res. Counc. Lond. Curr. Pap.* 410, 15 pp. + 4 tables + 15 figs., 1958.

The effects of various leading-edge modifications on the low-speed characteristics of a 6% thick R. A. E. 101 airfoil are discussed, with particular attention to the effects on the upper surface flow separations. In addition to the tests on the basic round-nosed section, the effects of attaching an isolated strake and a row of strakes to the leading edge were investigated. Tests were also made on a sharp-nosed version, both with and without deflected nose flap.

The results show that all the leading-edge modifications had profound effects on the upper surface flow separations. At the test Reynolds number (2×10^6), the upper surface of the basic round-nosed section exhibited a "short-bubble" flow up to 5° incidence, above which incidence a "long bubble" developed, which spread to the wing trailing edge by 10°. Addition of a row of strakes inhibited the bubble growth and allowed a certain degree of peak negative pressure to occur near the leading edge, but the particular configuration tested did not increase $C_{L_{max}}$ or reduce the overall drag coefficient at a given lift coefficient. Addition of a sharp leading-edge extension caused the "long-bubble" flow to develop from immediately above zero incidence. Deflection of the sharp leading edge caused the upper surface flow to remain attached, except for a localized region on the deflected nose, right up to the stall.

As a result of the changes in upper surface flow which were caused by the various leading-edge modifications, the chordwise pressure distributions and force and moment characteristics were also altered considerably.

A comparison is included between the measured pressure distributions and distributions calculated assuming no flow separations to be present. This comparison demonstrates the desirability of employing a calculation method which allows for the effects of the "long-bubble" separation.

From author's summary

4667. Hutton, P. G., Static response of a hemispherical-headed yawmeter at high subsonic and transonic speeds, *Aero. Res. Counc. Lond. Curr. Pap.* 401, 8 pp. + 10 figs., 1958.

Details are given of the static calibration of a hemispherical-headed differential pressure yawmeter, in the Mach number range from 0.6 to 1.2; the instrument has a central pitot pressure hole and two pairs of holes in perpendicular planes for flow-direction measurement.

The results show that the sensitivity to yaw (for angles up to 8°), as determined from pressure differences between opposing holes, varies smoothly with Mach number at transonic speeds; the sensitivity is little affected by a cross flow normal to the line joining the holes.

From author's summary

4668. Ferri, A., and Libby, P. A., The use of helium for cooling nozzles exposed to high temperature gas streams, WADC TN 55-318 (Polyt. Inst. Brooklyn, Dept. Aero. Engng. Appl. Mech.; ASTIA AD 94 314), 18 pp., July 1955 (reissued Nov. 1958.)

The results of preliminary theoretical analysis and tests of the use of helium as a cooling gas in hypersonic wind-tunnel and rocket-motor nozzles are presented. The helium is introduced tangential to the exposed surface from a slot located where the local Mach number is about 0.4. Thereby, an insulating layer of helium is formed between the exposed surface and the high-temperature gas stream. Helium appears to be the most appropriate insulating gas because of its high sonic velocity and because of its chemical inertness.

The theoretical analysis indicates that the method should be applicable over a wide range of stagnation conditions. The efficacy of the method is indicated by the results of some preliminary tests carried out in a nozzle operated from the heating system of the Hypersonic Facility of the Polytechnic Institute of Brooklyn. The stagnation conditions were between 1200 and 1800 F and 185–475 psia. Runs without cooling and with helium and cold air injected from the slot were made. Without cooling the throat the temperature continuously increased toward the stagnation temperature. With a helium mass flow of 3–4% of the main stream flow the throat temperature stabilized at approximately 1300 F less than stagnation. With air cooling, runs were made at 6 and 12% of the main stream mass flow; both resulted in throat temperatures approximately 800 F less than stagnation, although complete stabilization was not realized.

From authors' summary

4669. Sigalla, A., Measurements of skin friction in a plane turbulent wall jet, *J. Roy. Aero. Soc.* **62,** 576, 873–877, Dec. 1958.

Results of an experimental investigation of the distribution of skin friction along the wall of a plane turbulent wall jet are presented. The measurements show that it is possible to describe the variation of skin friction coefficient by a formula similar to the Blasius formula, which is based on experimental results of turbulent pipe flow. This is simply achieved by considering the inner layer of fluid between the wall and the position where the velocity is a maximum as a boundary layer with an outer uniform free stream of velocity equal to the local maximum velocity.

Other measurements of velocity distribution indicate that within the experimental range and accuracy, velocity profiles in the jet are similar and that the rate of change of velocity and width of the jet can be expressed by simple power laws. These results are then partially compared with theory.

From author's summary

4670. White, D. R., Influence of diaphragm opening time on shock-tube flows, *J. Fluid Mech.* **4, 6, 585–599, Nov. 1958.**

Paper discusses two causes of departure of shock tube performance from prediction of simple theory which assumes instantaneous diaphragm removal and entropy discontinuity (contact surface) between driver and driven gases.

Finite diaphragm rupturing time causes shock to form gradually, through steepening of nearly isentropic compression wave, with concurrent generation of upstream-facing expansion waves. In some instances, with large diaphragm pressure ratios, this process causes strength of transmitted shock to be appreciably greater than predicted for ideal model.

If heat capacities and temperatures of the two gases in contact zone are different, their mixing—which is promoted by jagged opening of diaphragm—is accompanied by change of volume. This change produces additional advancing or receding piston action (depending on relative heat capacities of gases employed) on remainder of flow, thereby strengthening or weakening shock. Effect of entropy production in flow through partially open diaphragm is not discussed.

Results of author's experiments provide good quantitative verification of theoretical predictions.

J. V. Foa, USA

4671. Henshall, B. D., The theoretical performances of shock tubes designed to produce high shock speeds, *Aero. Res. Counc. Lond. Curr. Pap.* 407, 6 pp. + 6 tables + 9 figs., 1958.

For the simulation in a shock tube of re-entry into the Earth's atmosphere at very high speeds, it is necessary to generate shock Mach numbers M_s up to 17. This upper limit on shock Mach number will simulate the velocity and stagnation temperature appropriate to the re-entry of an earth satellite. The production of strong shock waves is a difficult practical problem, and these extreme shock speeds have usually been attained by using "combustion" driver gases in the chamber of the shock tube. In this method a stoichiometric mixture of hydrogen and oxygen is ignited together with a helium diluent which forms about 75% of the total mass. [In some cases hydrogen has been used as the diluent.]

Particularly for large shock tubes, it is difficult to achieve controlled and complete burning without detonation: many experimental programs have been carried out to determine optimum mixing and igniting procedures and mixture compositions. Such studies have shown that combustion drivers are naturally erratic, and that a practical solution for one shock tube will not necessarily hold for another. It was with these facts in mind that the present study was initiated.

The theory of multiple diaphragm shock tubes using air throughout as the working fluid has been previously described by the author, and earlier results are simply modified to extend the calculations to the special case of a double-diaphragm shock tube with cold hydrogen driving argon which in turn finally drives air. This configuration can be conveniently denoted by ($H_2 \rightarrow A \rightarrow$ Air). It is shown that the performance of such a shock tube is comparable to that of a single-diaphragm shock tube using a combustion driver and having the same overall diaphragm pressure ratio.

From author's summary

4672. Rylands, H. D., A flight technique for the measurement of thrust boundaries and of drag due to lift, *AGARD Rep.* 123, 14 pp., May 1957.

Method proposed consists of measuring an accelerated level over the full available speed range at the required height and engine conditions, followed immediately by application of normal acceleration, still maintaining the height such that a fairly steady rate of loss of speed results through the speed range of interest. Thrust boundary can then be obtained by direct interpolation on lift coefficient at constant Mach number for zero longitudinal acceleration. In comparison with existing methods the new technique requires no lengthy flying program and involves no major assumptions in the analysis. Some data on drag due to lift can also be obtained without the need of thrust measurement.

E. Eujen, Germany

4673. Cockshutt, E. P., Levy, G. G., and Sharp, C. R., Laboratory and flight technique for the measurement of the temperature of turbine blading, *Nat. Aero. Establ., Canada, Lab. Rep.* LR 229, 11 pp. + 15 figs., Aug. 1958.

The evolution of a flight-worthy instrumentation system for measuring turbine rotor-blade temperatures in an Orenda 14 turbojet engine is described. The system comprises sheathed chromel-alumel thermocouples installed in drilled turbine blades and used in conjunction with mercury sliprings mounted in the exhaust bullet of the engine. The instrumentation has been used to measure under sea-level static conditions the turbine blade cooling produced by the pre-turbine injection of reheat fuel. An instrumented engine is currently being flown in a Sabre 6 aircraft to obtain similar data at altitude.

From authors' summary

Thermodynamics

(See also Revs. 4602, 4604, 4673, 4705, 4719)

4674. Woolley, H. W., Thermodynamic properties of gases at high temperature, *J. Res., Nat. Bur. Stands.* **61,** 6, 469–490, Dec. 1958.

The equilibrium thermodynamic properties of gaseous mixtures at high temperatures are treated by an extension of Ursell's cluster theory. An effective partition function is introduced from which the law of mass action and expressions for the second and third virial coefficients may be derived. Theory is extended to a partially ionized gas.

From author's summary by D. Ter Haar, England

Book—4675. van Ooijen, D. J., The thermoelectric power of copper, silver and gold after coldworking (Doctor's thesis), Gravenhage, Uitgeverij Excelsior, 1957, 126 pp.

Theoretical formulas of the thermoelectric power of metals are presented. The absolute thermoelectric power as well as the electrical resistivity of a metal is due to the electron scattering produced by thermal lattice waves, impurities and lattice defects. In coldworked metal, the thermoelectric power and the electrical resistivity are expected to increase owing to lattice defects introduced in it by the deformation.

Author measured the thermoelectric power against undeformed wires and resistivity of Cu, Ag and Au wires coldworked by drawing at room temperature or by rolling in liquid air, from liquid helium temperature up to room temperature. The recovery of this increase in thermoelectric power and resistivity due to annealing treatments was measured.

The experimental results, with the exception of anomalies of the absolute thermoelectric power at very low temperatures, can be explained by the above-mentioned theory. The analysis of experimental results shows that the recovery process consists of four steps which can be ascribed to four different types of lattice defects.

M. Kunugi, Japan

4676. Clark, D. D., A thermometer for high-speed aircraft, *J. Sci. Instrum.* **35,** 12, 433–439, Dec. 1958.

The principles of aircraft thermometer design are reviewed, from which it is deduced that the conical head design possesses distinct advantages over other kinds of thermometer head in high-speed flight. The construction of the thermometer is described

and the results of wind-tunnel tests are quoted and discussed. The lag and radiation errors are calculated and the extension of the use of the thermometer to supersonic flight is discussed. An outstanding feature of this thermometer is the remarkable constancy of the recovery factor over a range of Mach numbers from 0.2 to 0.9 and its rapid response to temperature changes, the lag coefficient being of the order of 2 s. From author's summary

4677. Wild, D., On the thermal conductivity of synthetic coals (in German), *Z VDI* **100,** 3, 95–99, Jan. 1958.

Author points out a simple and quick method for the measurement of thermal conductivity of synthetic coals, investigates the causes of error, and calculates the corresponding factors of correction. The method is applied to hard coals, natural graphites, graphitized coals, metalized coals, metalized graphites and sintered metals. From the results obtained, author infers that a law similar to that of Wiedemann-Franz for the pure metals is also valid for the graphitized coals and graphites, and, consequently, he deduces from it some criteria in order to get synthetic coals with a high thermal conductivity. C. Ferrari, Italy

Heat and Mass Transfer

(See also Revs. 4287, 4288, 4289, 4332, 4590, 4591, 4617, 4618, 4640, 4668, 4673, 4677, 4711, 4803)

4678. Kirkpatrick, E. T., and Stokey, W. F., Transient heat conduction in elliptical plates and cylinders, *ASME Trans.* **81 C** (*J. Heat Transfer*) 1, 54–60, Feb. 1959.

Mathematical treatment of heat conduction in elliptical cylinders presupposes, in general, an adequate knowledge in the theory of Mathieu functions, and the evaluation of theoretical results requires, moreover, reliable tables of those transcendents. However, there are no published values even of the simplest modified Mathieu functions and herein lies the fact that almost every result of this kind is only of theoretical character.

The paper in question presents one of the few exceptions, describing in detail numerical evaluation of certain theoretical results obtained formerly by N. W. McLachlan. Authors describe the computation of the modified function Ce_{2n}, give the values of its parametric zeros, and show how to evaluate certain integrals involving that function. It is a great pity that the unpleasant space limitations have prohibited the authors from publishing at least the values of Ce_{2n}. The knowledge of these values would greatly facilitate the work to other specialists interested in the subject.

Nevertheless, the paper is to be considered, even in its present form, as an unusually valuable contribution to numerical treatment of advanced problems on heat conduction.

V. Vodicka, Czechoslovakia

4679. Newcomb, T. P., The radial flow of heat in an infinite cylinder, *Brit. J. Appl. Phys.* **9,** 11, 456–458, Nov. 1958.

The solution is given to the transient flow of heat in an infinite circular cylinder with the boundary condition on the cylindrical surface specified as a linear function of time. The practical application of the result is cited as occurring with a band brake with which a moving vehicle is decelerated. Excellent agreement is obtained between an experiment and an analytical computation for flow of frictionally generated heat into a brake lining and a brake drum. The analytical computation makes no use of the cylindrical solution, as it removes the curvature effect by its approximations and reduces the solution (now applicable to both the inner drum and the brake lining) to the solution for the flow of heat in a semi-infinite solid contained in Carslaw. One would expect a good geometrical approximation to a brake band-brake drum system to be that of two parallel slabs with frictional heat generated at their interface. E. V. Somers, USA

4680. Colt, G., Beldiman, M., and Marinescu, St., Optimum thickness of thermal insulation for district heating pipes (in Roumanian), *Energetica* **6,** 11, 486–493, Nov. 1958.

The problem of computing optimum thickness in thermic insulation for hot-water transport pipes, considering Roumania's district heating conditions, is treated in some detail. Optimum insulation thickness for pipes with a 50–700-mm diameter is mentioned.

From authors' summary

4681. Kraev, O. A., Measuring of heat conductivity for metals in a wide range of temperatures during the experiment (in Russian), *Teploenergetika* no. 12, 69–72, Dec. 1957.

4682. Siegel, R., and Sparrow, E. M., Transient heat transfer for laminar forced convection in the thermal entrance region of flat ducts, *ASME Trans.* **81 C** (*J. Heat Transfer*), 1, 29–36, Feb. 1959.

An analysis is made for transient laminar heat transfer in the thermal entrance region of a flat duct (parallel plate channel) whose bounding surfaces are subjected to an arbitrary time variation of temperature of heat flux. Initially, the system may be either in an already established steady-state heat-transfer situation, or else the fluid and duct walls may be at the same uniform temperature. The velocity distribution in the flow is taken to be fully developed and unchanging with time. The solution for arbitrary time-dependent conditions is obtained by generalizing the thermal response to a unit step change in wall temperature or in wall heat flux. This step-function response is found by using the method of characteristics. Heat-transfer results are presented as simple analytical expressions. The time required to achieve steady state after a unit step is also given. Working formulas are summarized at the end of the paper.

From authors' summary by J. A. Clark, USA

4683. Labuntsov, D. A., Heat emission in pipes during laminar flow of a liquid with axial heat conduction taken into account, *Soviet Phys.-Doklady* **3,** 1, 33–35, Dec. 1958. (Translation of *Dokladi Akad. Nauk SSSR (N.S.)* **118,** 6, 1118–1120, Jan.-Feb. 1958 by Amer. Inst. Phys., Inc., New York, N. Y.)

Analysis assumes parabolic velocity distribution in circular pipe and physical properties to be independent of temperature. Constant wall temperature case and constant wall-heat-flux case were considered.

For former case, Nusselt number was shown to be a function of Peclet number with results tabulated for Pe^2 from 1 to 10^4. In latter case, Nusselt number is not dependent on Peclet number and remains equal to the constant value 4.36.

Reviewer found treatment very sketchy and difficult to follow. Little discussion or references to other work are given. Development does not appear to parallel classical solutions for nonaxial conduction, although constant flux result is identical to limiting value given by Sellers, Tribus and Klein [*Trans. ASME* **78,** p. 441, 1956; AMR **9** (1956), Rev. 1980]. A. Sesonske, USA

4684. Isachenko, V. P., and Salomzoda, F., Heat transfer and hydraulic resistance of pipes subjected to transverse flow of water (in Russian), *Teploenergetika* no. 11, 69–71, Nov. 1958.

Data are given on heat transfer and hydraulic resistance of a bunch of pipes with $s_1/d = s_2/d = 2$ in the region of Reynolds numbers corresponding to transition region of flow and heat exchange in the bunch. The approximate limits of this region are stated. From authors' summary

4685. Vaglio-Laurin, R., Turbulent heat transfer on blunt-nosed bodies in two-dimensional and general three-dimensional hypersonic flow, WADC TN 58-301 (Polyt. Inst. Brooklyn, Dept. Aero. Engng. Appl. Mech.; ASTIA AD 206 050), 41 pp., Sept. 1958.

Recent results obtained for three-dimensional laminar boundary layers are extended to the turbulent case. It is shown that in the

presence of highly cooled surfaces and of moderate Mach numbers of the outer stream, the crossflow and the pertaining Reynolds stresses in a general three-dimensional turbulent boundary layer are negligible even for large transversal pressure gradients. The demonstration assumes that Reynolds analogy is satisfied by the flow in the streamline direction; subsequently, the validity of this assumption is established by extending a correlation due to Mager between two-dimensional compressible and incompressible turbulent boundary layers. From a study of the transformation and of its implications, a rapid method for the analysis of the boundary layer flow under the subject conditions is established. In the absence of general three-dimensional data, a comparison with experiments and with the predictions of other known analyses is presented for several axisymmetric configurations; the results of the method proposed here exhibit good agreement with the data. The equations governing the mean motion in a general compressible three-dimensional turbulent boundary layer are derived in an appendix.

From author's summary

4686. Schenk, J., and van Laar, J., Heat transfer in non-Newtonian laminar flow in tubes, *Appl. Sci. Res.* (*A*) **7**, 6, 449–462, 1958.

Cup mixing mean temperatures and local Nusselt numbers are presented for a fluid obeying the Prandtl-Eyring stress-strain rate formula. Previously unreported data are the first two eigenvalues, eigenfunctions and Fourier coefficients for two values of a velocity profile parameter and only the lowest eigenvalues for five other values. Authors consider the influence of the thermal resistance of the wall on the fully-developed inside Nusselt number. An analysis of the effect of frictional heat dissipation is given in the appendix.

E. H. Wissler, USA

4687. Yaryshev, N. A., Application of Academician V. G. Galerkin's method to the solution of some problems in the theory of a regular thermal regime (in Russian), Investigations in the field of thermal measurements and appliances, Leningrad, 1957, 187–197; *Ref. Zh. Mekh.* no. 3, 1958, Rev. 3027.

Making use of Galerkin's method, approximate analytical relations were obtained between Kondrat'ev's criterion and other criterial values characterizing a regular thermal regime of the simplest isotropic single-dimensional bodies. The problem is solved for the boundary condition of the third order, when the linear principle of heat exchange between the surface of the body and the surrounding medium is in operation. Formulas were obtained for a cylinder and a sphere, both sloping and continuous, and also for an unbounded plate. Although when deducing the formulas only the first approximation was taken, the magnitude of the maximum relative error in the determination of Kondrat'ev's criterion did not exceed 1.3% for the plate, 3.8% for the cylinder and 6.4% for the sphere. Analogous formulas could easily be obtained for some compound bodies.

K. K. Vasilevskii

Courtesy Referativnyi Zhurnal, USSR

Translation, courtesy Ministry of Supply, England

4688. Bloom, M. H., and Pallone, A., Shroud tests of pressure and heat transfer over short afterbodies with separated wakes, WADC TN 58-185 (Polyt. Inst. Brooklyn, Aero. Lab.; ASTIA AD 155 690), 37 pp., June 1958.

Experimental measurements of pressures and heat-transfer rates over three blunt afterbodies of small fineness-ratio are presented. The afterbodies are generally similar in shape but have different step-down heights from the forebody.

Tests were made by means of a new shroud-technique over a range of Reynolds numbers closely corresponding to typical flight conditions at Mach numbers on the order of 20, considering models on the order of 5 feet in diameter at about 100,000-ft altitude. Stagnation temperatures on the order of 1300 R to 1600 R were employed. Surface temperatures varied between 560 R and 800 R.

A comparison is made with values obtained from tests of Chapman at Mach numbers on the order 2 or 3. Qualitative and some quantitative agreement is noted. The results are presented and compared with each other in terms of nondimensional variables based on flow conditions at the exit shoulder just prior to the afterbody.

The pressures are roughly uniform in the afterbody region. The ratio of afterbody pressure to forebody stagnation pressure decreases with increasing stagnation pressure. An adverse pressure gradient is noted on the exit shoulder.

Afterbody heat-transfer rates are also roughly uniform in a single run, although a measure of increase in the streamwise direction is noted. The Nusselt number-Reynolds number variation resembles a transitional variation ($N \sim R_s^2$).

From authors' summary

4689. Hama, F. R., and Christiaens, Jean, Experiment on the axisymmetric free-convection field along a vertically-suspended wire, AFOSR TN 58-444 (Inst. Fluid Dynam. Appl. Math., Univ. Maryland, TN BN-138; ASTIA AD 158 249), 15 pp. + 2 tables + 14 figs., May 1958.

In order to extend previous investigations on thick axisymmetric free-convection field to a higher range of the x-parameter, temperature profile along an electrically-heated vertical wire of 0.02-in. diameter and 5-ft length is measured by use of an interferometer. Experimental results are in good agreement with the theory. Together with the previous report [BN-116, Jan. 1958], this provides strong support for the theories of thick axisymmetric laminar boundary layers.

From authors' summary

4690. Gregg, J. L., and Sparrow, E. M., Low Prandtl-number free convection (in English), *ZAMP* **9a**, 4, 383–387, Nov. 1958.

4691. Ho, H.-T., and Probstein, R. F., A series solution to the laminar heat transfer problem at hypersonic speeds, WADC TN 58-263 (Brown Univ., Div. of Engng.; ASTIA AD 202 333), 35 pp., Sept. 1958.

A series-expansion technique is considered for solving the partial differential equations of compressible laminar boundary-layer flow. The idea of the method is that all flow quantities are expanded in a power series in an x-dependent variable, where x is distance along the body surface measured from the stagnation point, with the coefficients obtained from the solution of ordinary differential equations. The expansion variable depends on the external flow quantities and is defined through the Stewartson-Illingworth transformation which reduces the boundary-layer equations to their low-speed form. The method follows a scheme in its original form due to Blasius and involves the underlying assumption that the external velocity distribution can be expressed in a power series in the Stewartson-Illingworth (or other appropriate) x-dependent variable. In this scheme the zeroth-order solution is the stagnation point solution.

Axisymmetric flow is considered and specific results for surface heat-transfer rate on bodies of arbitrary shape are obtained up to terms of order x^2, although the method and equations are expressed to higher order. The actual numerical solution of the energy equation is partially analytic in that it is carried out by expressing the appropriate asymptotic system of ordinary differential equations as Weber equations, the solutions to which may be given in terms of parabolic cylinder functions. The assumption of a cooled body is made to simplify the pressure gradient term in the momentum equation in order that the momentum and energy equations may be solved separately. In addition, for simplicity in obtaining numerical results, the Prandtl and Lewis-Semenov numbers are taken equal to one and the product of the density and viscosity is taken constant. The numerical results for the heat-transfer rate which are obtained are empirically corrected to account for more realistic

fluid properties associated with a dissociated high temperature hypersonic boundary layer.

The analytic results obtained show that when the surface temperature is constant the heat-transfer rate distribution about a body divided by the thermal potential (total enthalpy minus wall enthalpy) is independent of the surface temperature under the assumptions previously given. Heat-transfer rate data in air on a hemisphere with a high temperature dissociated boundary layer are compared with the present calculations to terms of order $(x/R_b)^2$, where R_b is the radius of the hemisphere. Up to 60 degrees the agreement is quite good, which is very satisfactory since only terms of order x^2 have been used. Comparison of the calculated results with "local similarity" calculations is also made and the agreement there is also satisfactory, indicating a further justification for the use of the local similarity concept for the cases considered. For a modified Newtonian pressure distribution without the centrifugal correction where the stagnation pressure is small compared to the free stream pressure, and with γ the equilibrium isentropic exponent, the relation

$$\frac{-\dot{q}}{-q_{s+}} = 1 - \left(\frac{4.252 - 0.320\gamma}{6\gamma}\right)\left(\frac{x}{R_b}\right)^2 + 0\left(\frac{x}{R_b}\right)^4$$

is obtained for the ratio of the heat-transfer rate at one point on a hemisphere to the stagnation point heat-transfer rate for a polar angle up to approximately 60 degrees.

From authors' summary

4692. Baldwin, L. V., Slip-flow heat transfer from cylinders in subsonic airstreams, *NACA TN* 4369, 39 pp. + 2 tables + 20 figs., Sept. 1958.

Heat-transfer coefficients for normal air flow over an electrically heated 0.00022-in. diam wire were determined from the rate of heat loss and the wire and airstream temperatures. Heat losses were corrected for conduction to the wire supports, and the temperature driving force used in evaluating heat-transfer coefficients was the wire temperature less the recovery temperature of the airstream.

The data were correlated in terms of the Nusselt number hD_{wire}/k, the Reynolds number based on wire diameter, the Knudsen number, Kn = mean free path/wire diameter, and the temperature difference. (An additional variable is the Mach number; however, for any given gas, M is a function of Re and Kn.) The range of Kn covered in this study was from 0.009 to 0.077, in which region neither free molecular flow theory nor extrapolated heat-transfer correlations for continuum flow accurately predict heat-transfer coefficients. This region is referred to as slip flow and is considered to extend from $Kn \approx 0.001$ to 2.0. The data of the present work were found to extrapolate to empirical continuum flow correlations ($Kn < 0.001$) but at the same time showed certain characteristics predictable from free molecular flow theory. The usefulness of these data in predicting the sensitivity of hot-wire anemometers in the slip flow region is discussed.

A. W. Gessner, USA

4693. Yuan, S. W., and Barnzotti, A., Experimental investigation of transpiration cooling in turbulent pipe flow, ONR 839 16 (Polyt. Inst. Brooklyn, Aero. Lab. Rep. 479) 26 pp. + 18 figs., Aug. 1958.

The effect of coolant air injection at the wall on the velocity and temperature distributions of the turbulent flow in a porous-wall pipe has been experimentally investigated. The experimental apparatus was designed to establish a fully developed turbulent pipe flow at the entrance to a five-inch diameter porous-wall pipe test section. Main-stream Reynolds number was varied up to 300,000 for the isothermal case and corresponding weight flow for the non-isothermal case. The coolant flow to main-stream rates of 0.0008 to 0.018 was covered. The temperature range was between the ambient temperature and 900 F. The agreement between the theoretical results and the experimental data is found to be satisfactory.

The results show that the wall-friction coefficient increases with the increase of coolant injection whereas the heat-transfer coefficient decreases with the increase of coolant injection. Thus, the analog between the heat transfer and momentum transfer does not exist in transpiration cooling of pipe flow.

From authors' summary

4694. Jones, R. V., The detection of thermal radiation using linear expansion, *Proc. Roy. Soc. Lond.* (*A*) **249,** 1256, 100–113, Jan. 1959.

A thermal radiation detector is described which depends on the expansion of a thin metallic strip a few millimeters long. Expansions of the order of 10^{-12} to 10^{-10} cm are converted into rotations of 10^{-10} to 10^{-8} radians by means of a mechanical system using a galvanometer-type suspension strip as a flexure pivot. The rotations are measured with an optical lever and photoelectric amplifying system. Constantan 0.1 micron thick is employed as the expansion material, and the receiving area is about 1 mm^2.

The device was developed primarily to see whether the thermal fluctuation limit of sensitivity could be more closely approached than with conventional detectors. Observations on several of the best of the expansion devices show that they come within a factor of between two and three of the best possible sensitivity for a receiving area of 1 mm^2, achieving a noise equivalent signal of less than 1.5×10^{-11} watts for a bandwidth of 1 cycle/sec. In its present form the instrument is not very practical, but may possibly be improved.

From author's summary by C. F. Bonilla, Puerto Rico

4695. Adrianov, V. N., Application of the electric analogue method to the problem of radiant heat transfer (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk Energetika i Avtomatika* no. 1, 20–25, Jan. 1959.

The two integral equations which describe the process of radiant heat exchange in a closed system of surfaces with the absorbing and scattering medium present in an enclosure are shown to be sufficiently approximated by a system of linear algebraic equations. This scheme is equivalent to the solution of electric networks as first suggested by Oppenheim [*Trans. ASME* **78,** 725–735, 1956]. The problem is extended by the author to the case when the gas present in the enclosure is not at a constant temperature; however, the problem is still restricted to diffuse radiation from enclosing surfaces.

An electrical analog is given in the paper for the solution of the integral equations of radiant heat transfer with the help of an electrical integrator, but no specific problems are solved.

R. Viskanta, USA

4696. Adrianov, V. N., and Shorin, S. N., Radiant heat transfer in a flowing radiating medium (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 5, 46–53, 1958.

This paper is one of the first which is concerned with coupling of convective and radiative heat fluxes. The problem considered by the authors is a steady-state cooling of a radiating gas flowing in a circular pipe and between infinite parallel plates having a prescribed wall temperature. Convection and radiation are the two modes of heat transfer assumed to be present. The scattering of radiation is neglected and it is postulated that the radiant energy emitted by a unit volume of gas and absorbed by another unit volume is negligible compared to the radiant energy emitted by the gas and absorbed by the duct surfaces. The solution of a coupled system of equations of motion and the integrodifferential equation of energy conservation is eliminated by assuming one-dimensional flow and various velocity profiles in the ducts. The energy equation is solved and temperature distributions are determined for the following velocity profiles: for the circular pipe, – uniform and

parabolic, for the flow between two infinite parallel plates, – uniform, $u/u_0 = 3\,(1-b/b_0)^2$ and $u/u_0 = 3\,(b/b_0)^3$, where u is the velocity at any point b away from one of the plates, u_0 is the maximum velocity and b_0 is the distance between the plates.

Several new dimensionless numbers are introduced which enter radiative heat-transfer problems in a natural way; in particular a use is made of dimensionless parameter which governs the coupling between convective and radiative energy fluxes. The results of calculations are presented in graphical form as functions and parameters of dimensionless numbers. Some of the calculated results are compared with the predictions of other Russian investigators. R. Viskanta, USA

4697. Miropol'skii, Z. L., and Shneerova, R. I., Generalization of experimental data on temperature rates in metal of horizontal and slightly inclined boiling pipes (in Russian), *Teploenergetika* no. 6, 56–60, June 1958.

4698. Poletavkin, P. G., and Shapkin, N. A., Heat transfer at surface boiling of water (in Russian), *Teploenergetika* no. 5, 49–54, May 1958.

The results of an experimental investigation of heat transfer at surface boiling of water and their comparison with the experimental data obtained by ENIN, Academy of Sciences USSR, are given in the form of calculation formulas applicable to a wide range of the parameter variation of pipes and channels of different geometrical sizes. From authors' summary

4699. Styrikovich, M. A., and Miropol'skii, Z. L., The temperature regime of the work of horizontal and sloping steam-generating tubes at high pressures (in Russian), Hydrodynamics and heat exchange during evolution of steam in high-pressure boilers, Moscow, Akad. Nauk SSSR, 1955, 229–254; *Ref. Zh. Mekh.* no. 3, 1958, Rev. 3020.

Results are given for the experimental investigation of the temperature conditions of the work of horizontal and sloping tubes with inner diameters of from 32 to 56 mm, with angles of slope of from 0° to 10° and a pressure range of from 36 to 182 atm, and specific thermal flows of from 40×10^3 to 230×10^3 Kcal/m²/hr. The installation is described. The experimental procedure is given in detail. Many curves are produced. It was established that there exists a significant region of regimes where observation showed an increase of temperature of the metal in the upper part of the walls of the tubes in consequence of the irregular distribution of the steam and liquid phase by the section's height. This overheating may lead to damage due to the appearance of cracks or corrosion. It is explained that the overheating of the wall of tube Δt depends on its geometrical dimensions, the reduced velocity of the liquid and steam, the specific thermal flow and pressure during which Δt, with increase of the diameter of the tube and thermal flow, increases, while with increase of the velocity of circulation, it decreases. With increase of the reduced velocity of the steam, with other conditions the same, Δt first of all increases, and then decreases. With increase of pressure there is an increase of the boundary value of the speed of circulation at which Δt drops to a small size, of the order of 5–10°. With increases in the angle of slope up to 10°, Δt decreases at pressures up to 100 atm by approximately 3 to 4 times, and at higher pressures (140–180 atm) by approximately double. A deduction is put forward regarding the inadmissibility of the adoption of intensely heated horizontal tubes at high pressures in boilers with natural circulation. A. A. Gukhman

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4700. Chakrigin, V. G., and Lokshin, V. A., Temperature conditions for horizontal steam generating tubes under extra high pressures (in Russian), *Teploenergetika* no. 9, 58–63, Sept. 1957.

Test results are given on temperature conditions of horizontal steam-generating tubes under pressures of 180–220 atm and a heat flow of $4 \cdot 10^6$ k-cal/m²·hr. From authors' summary

4701. Aladiev, I. T., Dodonov, L. D., and Udalov, V. S., Heat transfer at boiling of underheated water in pipes (in Russian), *Teploenergetika* no. 9, 64–67, Sept. 1957.

The method and results of a study of heat emission at boiling of underheated water in pipes are given. Tests were carried out at pressures of 180 atm, heat loads up to $4 \cdot 10^6$ k-cal/m²·hour, circulation velocities up to 10 m/sec, and underheated water of saturation temperature from 1 to 140 C.

From authors' summary

4702. Gottesman, E., Efficiency of evaporative water cooling towers, *Appl. Sci. Res.* (*A*) **8,** 1, 28–44, 1958.

This paper describes a new method for calculating the interdependence of temperatures of the air and water streams which exists in an ideal, 100% efficient evaporative cooling tower and which pertains to various counter current air/water flow ratios. The interrelation is presented in the form of a graph, which facilitates the establishment of the average air/water flow ratio, prevailing in a real cooling tower, by means of the recorded initial and final enthalpy levels (temperatures) of the two streams. The graph enables also the determination of the minimum air/water flow ratio which is required for producing an equal water cooling effect in an ideal operation at the given initial enthalpy levels. The quotient of the two flow ratios (ideal/real) represents a new measure of cooling tower efficiency which is expressed in fractions of the ideal maximum heat absorption by the air stream. Conversely, the reciprocal value of this quotient, minus one (real/ideal – 1) represents the fractional amount of the prevailing excess air flow. Based on the reviewed principles of the evaporative cooling process, a series of conclusions are drawn with regard to the influence of some operational variables on tower performance. The computations presented in this paper refer to normal near atmospheric pressures. They have to be recalculated in accordance with the indicated method for application to cooling towers which operate at a different pressure level.

From author's summary

4703. Dusinberre, G. M., Calculation of transients in a cross-flow heat exchanger, *ASME Trans.* **81 C** (*J. Heat Transfer*), 1, 61–67, Feb. 1959.

This paper shows how transient temperatures in a cross-flow heat exchanger may be calculated by numerical methods. Digital computer programming is considered. A gas-turbine regenerator is used as an example. In particular, methods are developed which are useful when flow rates vary, as in the starting transient.

From author's summary by J. A. Clark, USA

4704. Hryniszak, W., Optimization of plate-type air preheaters for automotive gas turbines, *Trans. ASME* **80,** 8, 1791–1801, Nov. 1958.

The optimization, i.e. an economic balance, leads to the smallest possible weight for a given temperature and pressure efficiency of a plate-type heat exchanger for automotive gas turbines. Two further optimizations lead to the optimum pressure ratio for given initial temperatures and the best temperature and pressure efficiency. Further optimization leads to an optimum weight of the preheater at a given average speed. Cost is affected by the design and method of manufacture of the heating elements, by the choice of materials, and methods of maintaining clear channels.

From author's summary by W. Gumz, Germany

4705. Merk, H. J., The macroscopic equations for simultaneous heat and mass transfer in isotropic, continuous and closed systems, *Appl. Sci. Res.* (*A*) **8,** 1, 73–99, 1958.

Macroscopic equations for the transfer processes involving convection and molecular diffusion (from the laws of conservation of matter, of momentum and of energy) are derived. The effect of the diffusing heat capacities and the dependence of the enthalpy on the concentration are considered in the thermal energy equation. Author uses the results given by the thermodynamics of irreversible processes to relate the diffusion fluxes to the thermodynamic forces. The binary systems are studied and Maxwell's diffusion laws are obtained for the multicomponent systems. For these systems a simplified description of the thermal energy equation is indicated. A critical summary of the literature of the subject completes the paper. G. Sestini, Italy

Combustion

(See also Revs. 4619, 4722, 4762, 4763)

4706. Wolfhard, H. G., The ignition of combustible mixtures by hot gases, *Jet Propulsion* **28,** 12, 798–804, Dec. 1958.

Two types of hot-gas jet-ignition experiments were performed. Cold fuels or cold mixtures were ignited by hot air or hot inert gases and hot fuels were ignited in cold air. Results showed no relation between hot-gas ignition temperatures and either spontaneous ignition temperatures or minimum ignition energies. Relation is shown between hot-gas and hot-wire ignition temperatures. Author concludes hot-gas ignition is dependent on reaction rate at a given temperature and mass transfer.

F. W. Bowditch, USA

4707. Snyder, W. T., Influence of approach boundary layer thickness on premixed propane-air flames stabilized in a sudden expansion, *Jet Propulsion* **28,** 12, 822–825 (Tech. Notes), Dec. 1958.

Stabilization of premixed propane-air flames at edge of a sudden expansion is studied experimentally. Effect of approach length upstream of sudden expansion on blowout velocity is interpreted in terms of turbulent boundary-layer thickness at the trailing edge of the approach length. Thickening of the boundary layer resulted in an increase in blowout velocity as well as a widening of the stability limits. T. Y. Toong, USA

4708. Cole, B. N., Non-uniform burning in a high-speed parallel-sided combustor, Parts I, II, *Engineer, Lond.* **207,** 5373, 93–95, Jan. 1959; **207,** 5374, 129–132, Jan. 1959.

On the basis of one-dimensional reasoning, author develops equations for pressure drops and local Mach numbers in idealized gas-turbine-type combustion chambers under conditions in which combustion is confined to only a fraction of the total cross section of the airstream. Attention is given to flame length and post-combustion mixing. R. Friedman, USA

4709. Troshin, I. K., Gas dynamic analysis of non-stationary processes of flame propagation in pipes (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk* no. 1, 80–98, Jan. 1956.

Book—4710. Powell, H. N., and Suciu, S. N., edited by, Properties of combustion gases: Vol. I, Thermodynamic properties, System C_nH_{2n}—Air; Vol. II, Chemical composition of equilibrium mixtures, System C_nH_{2n}—Air, (Aircraft Gas Turbine Development Dept., G. E., Co.), New York, McGraw-Hill Book Co., li + 377 pp., and 677 pp. Two-volume set $75.

Here are 300 cubic inches and ten pounds of tabulated gas properties for a "typical" hydrocarbon fuel and air system. Volume I covers enthalpy, entropy, mean molecular weight, density, equilibrium and frozen sound velocities, specific heat and derivatives of mean molecular weight with respect to temperature and pressure. Independent variables are equivalence ratio from 0.25 (lean) to 4.00 (rich), pressure from 0.01 to 30 atmospheres, and temperature from 600 to 5000°R. Volume II tabulates $H_i°/RT$, $G_i°/RT$, $Si°/R$ and $cp°/R$ for A, C_{solid}, CO, CO_2, H_2, H_2O, N_2, O_2, O, OH, H, NO, N, NH_3 and CH_4 over the entire temperature range. It also has 658 pages of equilibrium composition values in terms of mol fraction for each constituent at each of the 20 equivalence ratios, and 22 pressures but only in the upper temperature range from 2500 to 5000°R. Results are given to five significant figures.

Any compilation must compromise between range and detail. Reviewer believes authors made an unfortunate choice in emphasizing detail and "precision." The tables apply exactly only to pure C_nH_{2n} fuels burned in perfectly dry air. Seldom does the power-plant engineer encounter such ideal conditions. Even if the C/H ratio is closely approximated, most real fuels have a per cent or so of sulfur. Most real air has a per cent or so of water. Consequently, five-figure precision would seem either useless or inaccurate. There is correspondingly little need for the small tabular intervals of temperature (100°R), pressure and composition. For design purposes, the main justification of this effort, it seems an extravagant use of space to report mol fractions of species which over much of the range have no bearing on composition up to five significant figures. Yet ammonia and methane are faithfully accounted for through all of Volume II even though their mol fractions hardly ever get above 10^{-5}. More serious is the omission altogether of important species. In the high-temperature fuel-rich region, for example, the equilibrium concentrations of hydrogen cyanide and acetylene can affect the third or even second significant figure.

The arrangement is convenient and the format is attractive. Noteworthy is the fact that the tables themselves have apparently been reproduced by a photographic process directly from the original computer printout. This technique avoids the errors and costs associated with typesetting or other transcription but it also surrenders any selectivity. The results are legible but hardly esthetic. The odd size (8½ × 11 in.) will make the volumes stick out conspicuously on the average bookshelf. This may not be objectionable to the engineer vitally concerned with combustion in completely dessicated air of a fuel in which the atom fraction of carbon is 0.33333 and that of hydrogen is 0.66666.

J. B. Fenn, USA

4711. Adrianov, V. N., Heat exchange of a flow of radiating products of combustion in a channel (in Russian), Avtorefer. Diss. Kand. Tekhn. Nauk, Energ. In-ta Akad. Nauk SSSR, Moscow, 1957; *Ref. Zh. Mekh.* no. 10, 1957, Rev. 11723.

4712. Millan, G., and Da Riva, I., Comparison of analytical methods for the calculation of laminar flame velocity, AFOSR TN 58-812, (Instituto Nacional de Technica Aeronautica Esteban Terradas, Madrid, ASTIA AD 202 357) 14 pp. June 1958.

4713. de Sendagorta, J. M., Prediction of the propagation velocity of laminar flame supported by a second-order reaction, AFOSR TN 58-770 (Instituto Nacional de Tecnica Aeronautica Esteban Terradas, Madrid, ASTIA AD 201 867) 8 pp., Apr. 1958.

4714. Boldman, D. R., and Blackshear, P. L., Jr., Study of some burner cross-section changes that increase space-heating rates, *NACA TN* 4162, 38 pp., Nov. 1957.

Experiments are presented on a premixed propane-air stream in ½-in. × 2-in. tunnel 12 in. long with turbulent flame stabilized behind 60° V-flameholder. Inserts downstream of flameholder provided symmetrical and asymmetrical blockage. Effect of blockage on space-heating rates was determined by photomultiplier technique [see Clark and Bittker, *NACA RM* E54 F29] and expressed as ratio of turbulent to laminar flame velocity. Conven-

tional pressure drop parameters are derived for the various blockage configurations. Symmetrical blockage giving finite length of restricted section gave the greatest increase in combustion efficiency. Upstream blockage reduced efficiency. Flameholder should be outside region of blockage to avoid combustion instability. Effect on blow-off limits has not been investigated. Authors suggest possible application to afterburner using small flameholder to give low drag without burning and high space-heating rates with burning. N. P. W. Moore, England

4715. Porter, C. D., Valveless-gas-turbine combustors with pressure gain, ASME-Gas Turbine Power Conf., Washington, D. C., March 1958. Pap. 58-GTP-11, 9 pp.

4716. Spalding, D. B., and Samain, M. D., The analogue solution of temperature distribution and extinction in an idealised cylindrical flame, AFOSR 58-216 (ASTIA 154 117), 10 pp. + 10 figs., Jan. 1958.

An idealized pilot burner is represented by a second-order differential equation over a finite range with a strongly nonlinear term subject to two point boundary conditions. The paper is largely a description of an analog consisting of a resistance network, a function generator and a rotating switch which generates a particular solution in a few seconds. The interesting feature of the solutions is that they predict extinction of the flame when the dimensionless reaction rate falls below a critical value. This value depends on the perforation pattern and the loading (ratio of the amount of gas burnt to the theoretical maximum).

Reviewer is not qualified to judge the novelty of the analog, but it appears to be a useful tool for a class of problems of practical interest. It is to be hoped that this report will be issued in a more convenient form. W. Squire, USA

Prime Movers and Propulsion Devices

(See also Rev. 4704)

4717. Buber, B. I., Investigation of the work of river-craft steam engines on the basis of the theory of similarity (in Russian), *Trudi Novosibir. In-ta Inzh. Vod. Transp.* no. 2, 205–211, 1956; *Ref. Zh. Mekh.* no. 3, 1958, Rev. 2853.

An analysis of the results of tests on river craft made it possible to establish the empirical relations between certain undimensioned qualities characterizing the work of the steam engines of these vessels. Application of these relations permits the determination of the optimum conditions for the work of the machine engine. S. S. Grigoryan

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4718. Brown, T. W. F., Propulsion of ships by steam turbine machinery, *J. Joint Panel Nuclear Mar. Propul.* **2,** 2, 57–113, Oct. 1958.

4719. Bulanin, V. I., A method for determining optimal parameters of gas-turbine installations (in Russian), *Teploenergetika* no. 8, 32–38, Aug. 1958.

A method is proposed for determining optimal parameters of complex gas-turbine installations (G. T. I.) for nominal conditions of operation. The equation systems are presented for determination of optimal parameters of two gas-turbine installations.

From author's summary

Book—4720. Lancaster, O. E., edited by, Jet propulsion engines (High Speed Aerodynamics and Jet Propulsion series, Vol. XII), Princeton, N. J., Princeton University Press, 1959, xvii + 799 pp. $20.

A 799-page engineering treatise on all forms of jet propulsion. Section A gives an interesting short history on airbreathing and rocket development. Section B presents basic principles, definitions, etc., of jet propulsion. Section C gives turbojet performance analysis including component matching, off-design analysis, control and testing problems. Following sections treat in similar detail the turboprop, ramjet, intermittent jets, liquid propellant rockets, solid propellant rockets, ram rocket and jet motors. A section on nuclear theory provides background for problems in using nuclear jet power suitable for aircraft. A final section by Zwicky provides a systematic (morphological) look at all kinds of jet propulsion schemes.

This book differs from previously published texts in the Princeton series in that a more empirical, engineering design approach is used, and the reader is referred to other volumes for detailed theoretical treatments. Text suffers from the fact that many sections were written nearly ten years ago and much has been developed and published in the interim. However, the many contributing authorities to this text have made a definite contribution and this book will serve as an important general reference in the propulsion literature. R. A. Gross, USA

4721. Papir, A. N., Some questions on the calculation for a water jet prime mover (in Russian), *Trudi Leningr. Politekhn. In-ta* no. 187, 58–72, 1956; *Ref. Zh. Mekh. no. 3, 1958, Rev. 2953.*

Taking into consideration the power of the prime mover and the characteristics of the pump, an attempt is made to establish basic principles for the selection of the parameters of the prime mover which would guarantee its having optimum qualities in regard to support and working of the pump without cavitation.

V. N. Gusev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4722. Andersen, W. H., Bills, K. W., Dekker, A. O., Mishuck, E., Moe, G., and Schultz, R. D., The gasification of solid ammonium nitrate, *Jet Propulsion* **28,** 12, 831–832 (Tech. Notes), Dec. 1958.

Article is concise and investigates the activation energy for the linear pyrolosis of ammonium nitrate. The gasification rate of solid was measured as a function of surface temperature, and a reaction mechanicism is suggested for the thermal decomposition. The conclusion is that the rate-collecting process occurs in the surface layer only. J. H. Davidson, USA

4723. Huth, J. H., What power sources in space? *Astronautics* **3,** 10, 24–26, Oct. 1958.

Magneto-fluid-dynamics

4724. Lykoudis, P. S., Channel turbulent flow of an electrically conducting fluid in the presence of a magnetic field, Purdue Univ., School of Aero. Engng. Rep. no. A-59-4, 19 pp., Mar. 1959.

Fully established turbulent flow in a channel is analyzed for an electrically conducting fluid in the presence of a magnetic field acting perpendicularly to the direction of flow. Velocity profiles, skin friction, correlation coefficients and distortion of the magnetic field are calculated for different values of the Hartmann number. From author's summary

4725. Yih, C.-S., Effects of gravitational or electromagnetic fields on fluid motion, *Quart. Appl. Math.* **16,** 4, 409–415 (Notes), Jan. 1959.

Extension of Proudman-Taylor's theory concerning the two-dimensional character of a weak steady rotational motion to motions with gravitational, magnetic and electric fields.

In all cases, for weak steady motion, the effect of the gravitational, magnetic or electric field is to "stiffen" the flow along two-dimensional surfaces like the rotational flow stiffens the weak flow along vorticity lines.

The mathematical analysis is carried out for all four cases.

S. Eskinazi, USA

4726. Kiselev, M. I., and Tsoplicev, V. I., Oblique shock waves in a plasma with finite conductivity, *Soviet Phys.-JETP* **7,** 6, 1104–1106, Dec. 1958. (Translation of *Zh. Eksp. Teor. Fiz.* **34,** 6, 1605–1607, June 1958 by Amer. Inst. Phys., Inc., New York, N. Y.)

The structure of an oblique shock wave in a plasma of finite and isotropic conductivity is considered. Viscosity and thermal conductivity are neglected. The conditions of applicability of the approximation are obtained. An estimate of the thickness of the wave is given. The limiting angle for the propagation of an oblique shock wave is obtained in a plasma of infinite conductivity. From authors' summary by R. Betchov, USA

4727. Majumdar, S. K., A note on magneto-hydrodynamics of a finite rotating disk, (in English), *ZAMP* **9a,** 4, 387–389, Nov. 1958.

4728. Alfven, H., Magneto-hydrodynamics of fusion (in Swedish), *Tekn. Tidskr.* **88,** 36, 917–918, Oct. 1958.

4729. Chuan, R. L., Preliminary results of plasma heating of high speed air flow, AFOSR TN 58 650 (Univ. So. Calif. Engng. Center Rep. 56–203; ASTIA AD 162 182, 8 pp., July 1958.

4730. Carter, A. F., and Wood, G. P., Effect of adsorbed nitrogen on the thermionic emission from lanthanum hexaboride, *NASA Memo* 2-16-59L, 12 pp., Mar. 1959.

The emission properties of lanthanum hexaboride in an atmosphere of nitrogen were investigated. The emitter was not poisoned by adsorbed nitrogen. This result should have application to magnetohydrodynamic devices. From authors' summary

4731. Winterberg, F., Nuclear combustion plasmas and magnetic nuclear combustion chambers for jet propulsion, *Astronaut Acta* **4,** 4, 235–263, 1958.

The properties of fusion and fission plasmas are discussed in connection with rocket propulsion. To prevent contact of the hot plasmas with the walls of the combustion chambers special arrangements of magnetic fields are proposed for confining the plasmas. For maintaining the necessary high magnetic fields a variety of methods for direct conversion of nuclear into electrical energy are considered. From author's summary

Aeroelasticity

4732. Movchan, A. A., On vibrations of a plate moving in a gas, *NASA RE* 11-22-58W, 19 pp., Jan. 1959.

Paper calculates the supersonic critical velocity for the flutter of a plate whose form is that of an infinite strip, with one edge clamped and the other free, and which moves through the air in its own plate with the free edge foremost. A detailed mathematical discussion is given of the nature of the eigenvalues and their dependence on the forward speed. W. S. Hemp, England

4733. Movchan, A. A., On the stability of a panel moving in a gas, *NASA RE* 11-21-58W, 21 pp. + 5 figs., Jan. 1959.

Paper examines the stability of a rectangular panel loaded in its plane and exposed to a supersonic airstream on one of its surfaces. Equations of motion are set up and the nature of the eigenvalues discussed with great mathematical precision using similar methods to those of preceding review. Formulas are obtained for the critical speeds, and numerical examples are given. W. S. Hemp, England

4734. Morgan, H. G., Huckel, Vera, and Runyan, H. L., Procedure for calculating flutter at high supersonic speed including camber deflections, and comparison with experimental results, *NACA TN* 4335, 23 pp. + 1 table + 8 figs., Sept. 1958.

Piston theory has been compared with quasi-steady second-order theory. The two expressions for pressure are of similar form and have been used to obtain complex oscillatory coefficients for lift on any area element of an oscillating wing for $M \gg 1$. Imaginary parts are proportional to frequency while real parts are independent. The coefficients are derivable for any deflection pattern–including chordwise bending–and are dependent upon airfoil thickness and shape.

A conventional flutter determinant has been set up using normal modes as generalized coordinates, and has been solved by "Materiel Center" method.

Numerical results have been compared with experiment for several wind-tunnel models having essentially zero thickness. Findings are inconclusive except to indicate that flutter speed calculated by either method is within ± 10% of measured values. Report contains little contribution to basic state of the art and is primarily procedural. Its value would have been enhanced by more attention to engineering procedures and less to the mathematical representation of standard derivations.

C. D. Pengelley, USA

4735. Miles, J. W., On panel flutter in the presence of a boundary layer, *J. Aero/Space Sci.* **26,** 2, 81–93, 107, Feb. 1959.

Author considered the problem of panel flutter in previous papers [*J. Aero. Sci.* Aug. 1956 and Feb. 1957; AMR **11** (1958), Rev. 256]. In the present paper the influence of the boundary layer on panel flutter is discussed. It is found that the energy transfer from the outer flow to the panel consists of two components. The first is the usual energy transfer due to the acoustic coupling between surface waves on the panel and sound waves in the outer flow. It is found to be reduced by the presence of the boundary layer. The second component is intrinsic to the shear flow and is positive whenever the surface wave speed is smaller than the free-stream speed. The approximation to the shear flow model is similar to that adopted in the stability problem of a laminar boundary layer. The differential equation for the disturbed motion of the boundary layer has a similar singularity in the point where the local flow speed is equal to the surface wave speed. This singularity is the cause of the second energy transfer component.

The conclusion is that in supersonic flow the boundary layer reduces the instability, while in subsonic flow the instability would have to be due completely to the shear flow energy transfer which, however, is much too small to compensate the positive damping due to the acoustic coupling.

A. I. van de Vooren, Holland

4736. Higdon, D. T., Effects of large wing-tip masses on oscillatory stability of wing bending coupled with airplane pitch, *NASA Memo.* 12-29-58A, 32 pp., Jan. 1959.

"An examination of oscillatory wing-bending stability for a straight-winged airplane with large concentrated wing-tip masses was made using wing-bending and airplane-pitching degrees of freedom and considering only quasi-steady aerodynamic forces. It was found that wing-bending instability caused by coupling of airplane pitching and wing-bending dynamics occurred. Actual conditions for this instability are given in terms of a number of

dimensionless quantities which describe the airplane and its flight condition."

The care with which the author handled the mathematical notation is commendable and permits the reader to follow the text without reference to standard texts on mathematics or vibration problems. S. J. Zand, USA

4737. Broglio, L., Modeling technique and theory for aeroelastic similarity in blow-down wind tunnel tests, AFOSR TN 58-902 (Universita di Roma, Scu. Ingeneria Aero., SIAR 30; ASTIA AD 204 283), 133 pp., Mar. 1958.

Author considers the problem of aeroelastic similarity for wing and wing-tail models used in wind-tunnel tests. A procedure is described for designing aeroelastically similar wind-tunnel models. Linearized supersonic flow theory, neglecting thickness effects, is applied to the calculation of deflections of an elastic, uncambered wing with supersonic leading and trailing edges. Structural influence coefficients for the wing are assumed known.

Mach 3 wind-tunnel data is presented for three sweptwing models, tested with and without a tail. Wing models were made of steel, an aluminum alloy, and a magnesium alloy. Model elastic deflections were measured optically, and aerodynamic loads measured by means of strain gage balances.

Calculated model deflections and aerodynamic loadings, based on the theory presented, compare fairly well with experimental data. W. G. Brady, USA

4738. Alyamovskii, M. T., and Prokof'ev, K. A., Approximate method for the determination of the amplitudes when condenser tubes are in a state of self oscillation due to the action of aerodynamic forces (in Russian), *Sudostroenie* no. 7, 7–12, 1956; *Ref. Zh. Mekh.* no. 11, 1957, Rev. 12645.

Authors carried out experiments which showed that a transverse flow of gas near a group of circular cylinders placed parallel to and at fixed distances from each other may arouse vibrations in the cylinders principally in the plane perpendicular to the direction of the flow. In addition to this, in all the cylinders, with the exception of those situated in the first row, the vibration amplitudes increase with the velocity of the flow, while the frequencies remain constant and equal to the frequencies of the tubes.

In individual cylinders the amplitudes of vibration have a maximum close to the critical value $C_*(R)$ and when Strouhal's number has a value of 0.2, if for the frequency the value f is adopted. Vibrations of this kind are also produced in the tubes of ships' condensers. Authors have worked out and propose a semi-empirical means of calculating the vibrations of condenser tubes, based on a series of simplifying assumptions relating to the harmonic oscillations of any point along the length of the tube, the harmonic aerodynamic force, exciting oscillations of the same frequency, the expressions of kinetic energy of the oscillating tube, the form of relationship of the aerodynamic force to the amplitude of oscillation, and so forth.

In order to complete the calculations in each case it is necessary to obtain by experiment: the shape of the elastic line of the oscillating tube and its natural frequency, the relation of the damping decrement to the amplitude of the oscillations of any point on the tube, etc. To substantiate the claims of this method of calculation and to obtain the basic relations a series of experiments was made with bundles of cupronickel tubes in a free stream. In one case a calculation for the vibrations and its experimental check showed satisfactory agreement.

S. G. Popov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Aeronautics

(See also Revs. 4381, 4637, 4645)

Book—4739. Stewart, O., Danger in the air, New York, Philosophical Library, 1958, xx + 194 pp. $6.

Author, who is editor of the British magazine *Aeronautics,* examines the causes of aircraft accidents by means of well-selected examples, almost all of which are from British experience, though some involve American-built planes. Insisting upon the educational value of studies of this kind, he remarks, "The human side of such accidents has been extensively written about. Here I treat the technical side."

Most of the examples are from the post-World-War-II decade, but the R-101 airship is included and there is an interesting discussion of the fatal accidents of Lilienthal and Pilcher in the 90's. Among the causes of accidents covered are poor instrument readability, faulty controls, crew fatigue, poor maintenance, storms, icing, sabotage, structural failure and structural fatigue. The latter two are illustrated respectively by the breakup of a De-Havilland 110 at the 1952 Farnborough show after a sharp pull-out, and by the Comet disasters of 1954. There is no mention of aeroelastic phenomena as causes of air accidents, a serious omission.

In reviewer's opinion, the chapters on the R-101 and on the Comet leave much to be desired. Stewart is in fact not technical at all in discussing structural matters, and there is no hint that the Comet failures were not fatigue in the usual engineering sense. Since relatively few cycles were required to produce failure, the trouble seems to have been more basically due to the influence of a biaxial stress field on material ductility.

The discussion of the R-101 differs from other recent accounts in implying that there was no reason why that ill-designed ship should not have left for India on Oct. 4, 1930, although it had had (following the insertion of an entire new bay) only a single test flight, which was seriously hampered by engine trouble. The mention of other airship accidents in this same chapter, while the safety value of helium is minimized, finally leaves the reader with a firm impression that for some mysterious and indefinable reason, rigid airships are unsafe. In view of the prevalence of such sloppy thinking on this subject, it is perhaps worth pointing out that rigid airship development has stagnated for political and economic reasons (the validity of which cannot be argued here) and not for structural or aerodynamic ones (see, for example, E. Kirschner, "The Zeppelin in the atomic age," University of Illinois Press, 1957).

Author's opinions are for the most part worth listening to, however, and he argues strongly for parachutes in commercial aircraft, flying boats on over-water routes, and less promiscuous blame of "pilot error" in accident investigations.

A. D. Topping, USA

4740. Tipei, N., and Guta, C., Motion of an aircraft on a given path (in Roumanian), *Studii si Cercetari Mecan. Appl.* **9,** 4, 855–866, 1958.

Proceeding from the idea that most of the actual evolutions in vertical plane are performed on paths that may be assimilated with conveniently chosen conics, authors discuss the case of rescue on the three types of conics and determine the dynamic elements of these motions. The method employed is faster than that of successive arcs and may cover with a certain degree of accuracy most of the aircraft evolutions in vertical plane.

M. Ionescu, Roumania

4741. Pavlics, F., A new booster of lift and thrust for amphibian vehicle, U. S. Army Ordnance Corps, OTAC Rep. 32, 41 pp., May 1958.

Amphibian vehicles lack mobility in water, particularly when landing or descending into the water.

To overcome this deficiency a paddle track was conceived as a booster of lift and thrust. Preliminary tests indicate certain advantages which this device may possess over such conventional solutions as buoyant floats, screws, or hydrojets. Further detailed investigations of the idea appear advisable and may be most promising when designing new amphibian vehicles.

From author's summary

4742. Opatowski, T., The stability of flying platform-type helicopters, *J. Helicop. Assn.* **12,** 5, 238–262, Oct. 1958.

Control of flying platforms through body movements of the pilot is analyzed using standard stability equations and techniques. Presentation is clear and interpretations of results are well presented. The graphical results for a typical numerical example are included.

Moments applied by pilot at his ankles are assumed linear functions of tilt, horizontal velocity, and their first derivatives. Vertical velocity is neglected and ground position is not explicitly controlled. If delay in pilot response and lag in thrust vector are both assumed zero, stabilization is always possible through controlled moments of the same order as those used in standing upright. Including pilot delay, increased stability and ease of control results from high system and platform inertias and low weight and c. g. of pilot. Assuming only thrust vector lag, low weight and c. g. for pilot improves stability while high platform inertia or low platform plus pilot inertia is desirable. Small or even negative lag, attainable by increase in differential drag due to change of induced drag during pitch, permits greater range in control constants.

For general case, minimizing weight and c. g. height of pilot results in low moment requirements and maximum permissible delay times and thrust lags. Increasing pitch inertias increases permissible delay times. Permissible thrust vector lag is increased by increasing platform pitch inertia and, to a lesser extent, by reducing overall system inertia. Reduction of thrust vector lag increases permissible pilot delay time.

E. T. Welmers, USA

4743. Payne, P. R., Higher harmonic rotor control, *Aircr. Engng.* **30,** 354, 222–226, Aug. 1958.

The elimination of the retreating blade stall speed limitation for helicopters by means of an appropriately programmed feathering input is studied for the general case of a rigid flapping blade with hinge constraint (thus making the results applicable to conventional, offset-hinged or cantilevered rotor blades).

It is concluded that second harmonic feathering alone will not be particularly effective in delaying the stall limit, but that a suitable program of several higher harmonic inputs will enable the retreating blade stall limit to be pushed beyond the advancing blade compressibility limit.

In the course of the investigation generalized equations were developed for blade flapping to the *n*th harmonic under the influence of feathering to the *n*th harmonic. The resultant matrix is symmetrical and checks with the few available limit cases derived by other workers. Because of loose coupling in the matrix generalized equations can be derived giving the effect of any particular harmonic of feathering upon flapping and angle of attack distribution around the disk.

The effect of higher harmonic feathering upon rotor stability derivatives is not discussed in this text, but examination of the equations indicates that an improvement in stability could be obtained by the application of second harmonic control.

This paper does not discuss the mechanical details of obtaining a higher harmonic feathering input, nor is it suggested that this is necessarily the best means of obtaining higher forward speeds. In certain cases it may be the only means however.

From author's summary

Astronautics

(See also Revs. 4476, 4633, 4636)

4744. Bacon, R. H., On the retardation of a satellite, *Amer. J. Phys.* **27,** 2, 69–72, Feb. 1959.

Consider a satellite moving in an inverse-square gravitational field, neglecting the effects of the Moon and the Sun.

Using the method of the "variation of the elements," author calculates the effects of discrete tangential impulses received by the satellite at various points along its elliptic orbit. He shows that at the vertices of the orbit the loss of potential energy alone is greater than the loss of the total energy caused by any single retarding impulse. As a consequence of this, a retarding impulse received at any point of the satellite's orbit results in a gain of kinetic energy at some other point of the orbit, this gain being greater than the loss of total energy incurred at the point at which the impulse was received. The retardation of the satellite may be considered as the resultant effect of an infinite succession of such infinitesimal tangential impulses.

E. Leimanis, Canada

4745. Persen, L. N., Motion of a satellite with friction, *Jet Propulsion* **28,** 11, 750–752 (Tech. Notes), Nov. 1958.

Author assumes a mass point system and sets up appropriate equations where friction force is assumed to be proportional to some power of the satellite's velocity and the density of ambient gas is assumed to decrease with distance from the geo-center. Two specific cases are taken; in the first, satellite drag is assumed proportional to the square of the velocity, and density is assumed to vary inversely as the distance from the geo-center. A simple exact solution to the resultant equations is obtained assuming that the orbit will be approximately circular and hence that the radial component of friction is negligible. The second case solved by the author eliminates the assumption of near circular orbits, and assumes drag directly proportional to velocity, with density decreasing proportional to the reciprocal of the square of the distance from the geo-center. The resultant equations are solved to yield orbits which are elliptical spirals. The results are applied to estimate the lifetime of Sputnik I. Many more elaborate analyses of this problem exist in the literature today; the interesting feature of this analysis is its simplicity and tractability.

G. V. Bull, Canada

4746. Leon, H. I., Angle-of-attack convergence of a spinning missile descending through the atmosphere, *J. Aero/Space Sci.* **25,** 8, 480–484, Aug. 1958.

Author presents analysis of relatively blunt re-entry body for altitudes above that for maximum heating. Analysis neglects aerodynamic damping, velocity change, and flight-path-angle change. Result shows less rapid convergence with spin than without it.

A. E. Bryson, Jr., USA

4747. Egorov, V. A., Some problems of the dynamics of flight toward the moon (in Roumanian), *Analele Romino-Sovietice, Ser. Matem.-Fiz.* **12,** 2, 45–95, 1958.

Paper presents a synthesis of results obtained at the Institute of Mathematics of the USSR Academy of Sciences within the years 1953–1955.

Problem is reduced to three bodies: earth, moon and rocket, for which the restricted circular problem is considered. Treatment procedes from the energy integral in compliance with the method indicated by Hill. The problem of minimum initial veloc-

ities is solved and the procedure for the numerical determination of a minimum velocity trajectory is shown.

The possibility that a body launched from the earth is captured by the moon is discussed. Impossibility of capture is proved in case of approaching trajectories (starting from earth and approaching the moon during the first rotation). By establishing the evolution of approaching trajectories as a function of the initial velocity and its direction, the main problems of the dynamics of a flight toward moon in the plane of its orbit are solved. Methods for determining by means of electronic computers the initial data for reaching the moon, for flying round the moon and for returning to earth are given. The flight round the moon with oblique penetration into the earth atmosphere is also discussed, and the impossibility of periodical plane flights round the moon and earth on approaching trajectories is shown.

Paper also includes indications on the possibility of accelerating a rocket through the moon attraction when flying toward other planets or toward planets exterior to the solar system.

N. Tipei, Roumania

4748. Taratinova, G. P., On the motion of an artificial satellite in the gravitational field (in Roumanian), *Analele Romino-Sovietice, Ser. Matem.-Fiz.* **12**, 1, 32–41, 1958.

Proceeding from the differential equations of motion under a general form, author gives a method for calculating the orbit and the motion elements by means of electronic computers, the air drag and the deviation of gravitational field from a central field being taken into account. The disturbing effects of both sun and moon, being very small, are neglected. A system of six differential equations is obtained, taking as independent variable the number of the satellite rotations and as unknown functions the ρ parameter of the orbit, its eccentricity, the angular distance of perigee from the ascending point, the longitude of ascending point, the inclination of orbit and the time.

As an application, the orbit of a 10-kg and 0.5-m-diameter spherical satellite, having as initial values of the apogee and perigee altitude 1285 km and 320 km respectively, is calculated. Calculation of the orbit in compliance with the above method for a two-year motion required four hours. N. Tipei, Roumania

4749. Sohn, R. L., A proposed Kepler diagram, *ARS J.* **29,** 1, 51–54 (Tech. Notes), Jan. 1959.

Author offers a Kepler diagram showing integrated equations of motion, with shape of trajectory, velocity, time, flight path angle and transit angle along the trajectory. He uses dimensionless units, ratios of kinetic to potential energy, instantaneous to apogee velocity, time from apogee to total period. The chart is suited to determining burnout conditions for required apogee altitude and solving other problems in the study of ballistic missiles. A. A. Bennett, USA

4750. Roberson, R. E., Torques on a satellite vehicle from internal moving parts, (Supplement), *J. Appl. Mech.* **25,** 2, 287–288 (Brief Notes), June 1958.

4751. Sandorff, P. E., Optimization of space vehicle design with respect to propulsion system, AFOSR TN 58-580 (Air Force Office of Scientific Research, Mechanics Div,; ASTIA AD 158 402), 6 pp. + 2 tables + 2 figs., July 1958.

Ballistics, Explosions

(See also Rev. 4447)

4752. Deal, W. E., Measurement of the reflected shock Hugoniot and isentrope for explosive reaction products, *Physics of Fluids* **1,** 6, 523–527, Nov./Dec. 1958.

When a detonation wave impinges on an interface with an inert material a wave is reflected into the burned gases. Varying the impedance of the inert material to the detonation wave changes the character (shock or rarefaction) and strength of reflected wave. Measuring hydrodynamic state of inert and matching conditions at interface gives a data point on the reflected shock Hugoniot or on the isentrope below the Chapman Jouguet (CJ) state of reacted gases. Using a series of inert materials, which yielded pressures behind reflected shock of 551 to 515,000 bars, authors determined the Hugoniot and isentrope. Data for the isentrope could be correlated with p/ρ^{γ} = constant; for Composition B (64/35/1 : RDX/TNT/wax by weight), $\gamma = 2.77$. If a polytropic equation for the isentrope is assumed, determination of the hydrodynamic state of a single inert establishes the CJ state of explosion products provided density of explosive and detonation velocity are known. A. Fuhs, USA

4753. Fickett, W., and Wood, W. W., Detonation-product equation of state obtained from hydrodynamic data, *Physics of Fluids* **1,** 6, 528–534, Nov./Dec. 1958.

Recent experimental measurements [see preceding review] of the isentrope for detonation gases from Composition B combined with experimentally determined detonation velocity as a function of density of explosive provide considerable information concerning the equation of state. These experimental data are not sufficient to give the equation of state without additional assumptions. Reasonable assumptions were made and the corresponding equation of state was tested by calculating temperature of reaction, detonation Hugoniot, heat capacity ratio, and similar quantities which were then compared with experimental results. Internal energy of products can be represented by a simple function of pressure and volume.

A. Fuhs, USA

4754. Hubbard, H. W., and Johnson, M. H., Initiation of detonations, *J. Appl. Phys.* **30,** 5, 765–769, May 1959.

A particular, numerical integration of the equations governing initiation of detonation in solid explosives has been performed. A simplified model of one-dimensional nonsteady flow is used, with heat release governed by an Arhennius-Eyring reaction rate and with an equation of state suitable for solid explosives. To avoid difficulties in integration caused by shock discontinuities, the method of von Neumann and Richtmyer is used, by which an artificial viscosity term is introduced to "smear out" the shock into a continuous transition larger than the mesh size. The resulting equations are integrated, subject to an initial rectangular pressure pulse applied to the explosive. The energy- and pressure-time curves obtained consist of a shock-heating zone followed after a significant delay by a regime of fast reaction which leads to establishment of a stable detonation. Authors suggest as criterion for detonability the size of the minimum pressure pulse which will shock-heat the explosive for a period sufficient to overcome the delay, and ensure initiation of the fast reaction. Qualitative discussion of factors influencing this criterion is presented, but lack of data concerning properties of medium under high-speed compression conditions is shown to limit usefulness of this approach.

R. A. Stern, USA

4755. Bowden, F. P. (edited by), A discussion on the initiation and growth of explosion in solids, *Proc. Roy. Soc. Lond.* (A) **246,** no. 1245, July 1958.

Instead of discussing the individual papers, authors and titles are enumerated. Papers not in the field of Applied Mechanics Reviews have been omitted.

It should be noted that this collection of papers is an excellent contribution describing the state of the art.

4756. Bowden, F. P., Introduction, 146–154.

4757. Cook, G. B., The initiation of explosion in solid secondary explosives, 154–160.

4758. Johansson, C. H., The initiation of liquid explosives by shock and the importance of liquid breakup, 160–167.

4759. Bryan, G. J., and Noonan, E. C., Energy requirements for the ignition of seven solid explosives, 167–175.

4760. Evans, J. I., and Yuill, A. M., Initiation of condensed explosives by compression of the surrounding gas, 176–180.

4761. Rice, F. A. H., and Levine, D., Studies on the oxidation induced by ultrasonic radiation on a solid system lauryl aldehyde and potassium chlorate, 180–188.

4762. Wyatt, R. M. H., Moore, P. W. I., Adams, G. K., and Sumner, J. F., The ignition of primary explosives by electric discharges, 189–196.

4763. Garner, W. E., Thermal decomposition, inflammation and detonation, 203–206.

4764. Yoffe, A. D., The growth of explosion in solids, 254–257.

4765. Andreev, K. K., Some considerations on the mechanism of initiation of detonation in explosives, 257–267.

4766. Cachia, G. P., and Whitbread, E. G., The initiation of explosives by shock, 268–273.

4767. Eichelberger, R. J., Sympathetic detonation and initiation by impact, 274–281.

4768. Cook, M. A., Pack, D. H., and Gey, W. A., Deflagration to detonation transition in solid and liquid explosives, 281–283.

4769. Marlow, W. R., and Skidmore, I. C., The initiation of condensed explosives by shock waves from metals, 284–288.

T. P. Torda, USA

Acoustics

(See also Revs. 4441, 4761)

4770. Barger, R. L., Reflection and transmission of sound by a slotted wall separating two moving fluid streams, *NACA TN* 4295, 12 pp. + 2 figs., June 1958.

Title problem is treated for the case of an incident plane acoustic wave whose normal is parellel to the slots. Because of the great mathematical difficulties of a rigorous formulation an approximate treatment is given for sufficiently low frequencies (wavelength large compared to slot geometry and boundary layer) and for points several wavelengths away from the plane of the slots. Under these restrictions the slotted plane is replaced by a homogeneous boundary having a certain virtual mass per unit area. Introduction of this virtual mass into the boundary condition (conservation of momentum) leads to the determination of the acoustic reflection and transmission coefficients.

H. L. Oestreicher, USA

4771. Skalak, R., and Friedman, M. B., Reflection of an acoustic step wave from an elastic cylinder, *J. Appl. Mech.* **25,**1, 103–108, Mar. 1958.

See AMR 11 (1958), Rev. 3803.

4772. Kliachkin, V. I., The effect on a receiving system of a set of independent noise sources located on the surface of a finite-radius sphere, *Soviet Phys.-Acoustics* **4,** 2, 153–160, Dec. 1958. (Translation of *Akust. Zh.* **4,** 2, 153–160, Apr.–June 1958 by Amer. Inst. Phys., Inc., New York, N. Y.)

Mathematical expressions are obtained for the concentration coefficient and the directivity characteristic of a receiving surface in the sound field of statistically independent point noise sources placed uniformly on the surface of a nearby radiating sphere of finite radius. The following types of receiving systems are considered in detail: (1) linear pickup; (2) disk with uniform sensitivity; (3) parabolic reflector. The methods of the correlation theory of random processes are used.

R. Heller, USA

4773. Mikhailov, I. G., and Marenina, K. N., The absorption of the ultrasound waves in suspensions (in Russian), *Vestnik Leningrad Univ.* no. 22, 56–74, 1956.

The theory of absorption of ultrasonic waves in aqueous suspensions, worked out by Lamb, later by Rytov, Vladimirskii, Galanin and independently by Urick, is in satisfactory agreement with the experiments. According to prediction of the theory: (a) Absorption coefficient α_w varies linearly with the concentration. (b) Absorption coefficient α_f (due to friction) depends upon the size of suspended particles. First, with increase in size of particles, α_f increases directly with r^2, reaches maximum value and then decreases directly with $1/r$. (c) Absorption coefficient α_s (due to diffusion) increases rapidly with the growth of particles in size or increase in frequency, $\alpha_s \sim \nu^4 r^3$. (d) Absorption coefficient α_w depends upon frequency. First, at low frequencies, α_w varies directly with ν^2, then directly with $\sqrt{\nu}$ and, finally, due to increase in diffusion effect, directly with ν^4.

Time relaxation τ in the system of mercury emulsion and suspended kaolin in water, obtained in the experiments of Vladimirskii, Galanin and Urick, are in satisfactory agreement with theoretical calculations.

From authors' summary by A. N. Petroff, USA

4774. Rao, K. S., and Rao, B. R., Ultrasonic studies on some aqueous solutions of electrolytes, *J. Sci. Indust. Res. India* **17 B,** 11, 444–447, Nov. 1958.

4775. Krishnamurty, Bh., Ultrasonic studies in liquid mixtures, *J. Sci. Indust. Res. India* **17 B,** 10, 397–399, Oct. 1958.

4776. Hojgaard Jensen, H., and Saermark, K., On the theory of the Rayleigh-disk and the sound pressure radiometer (in English), *Acustica* **8,** 2, 79–86, 1958.

Authors calculate the radiation pressure exerted by a plane sound wave impinging upon an infinitely long rigid strip and a circular disk. Explicit expressions in terms of Mathieu and spheroidal functions are given for the mean torque (Rayleigh disk) and the mean force (sound pressure radiometer) acting upon strip and disk. The series expansions are numerically evaluated and mean force and torque plotted as functions of ka for values of ka up to 5 (k wave number, $2a$ diameter of disk or width of strip). The results are discussed and compared with experimental values.

H. L. Oestreicher, USA

4777. Riznichenko, Yu. V., Silaeva, O. I., Shamina, O. G., Myachkin, V. I., Glukhov, V. A., and Vinogradov, S. D., Seismic-acoustic methods of study of the stressed condition of rocks from samples and in situ (in Russian), *Trudi Geofiz. In-ta Akad. Nauk*

SSSR no. 161, (34), 74–163, 1956; *Ref. Zh. Mekh.* no. 11, 1957, Rev. 13248.

An investigation is made of different methods of examining the stressed condition of rocks. Attention is basically apportioned to the impulse and acoustic methods. It is shown that with increase of pressure the modulus of elasticity in rocks increases more rapidly than the density. Consequently the velocity of sound, proportional to the root of the square from the relation of the modulus of elasticity to the density, increases with the increase of pressure; the velocity of sound is approximately proportional to the root of the sixth order from the pressure. It is recorded further that at the beginning of destruction the formation of cracks in rocks is accompanied by crackling. The study of vibrations appearing in the rock strata during destruction lies at the basis of the acoustical method. The apparatus used in the laboratory is described for the study of the velocity of sound in stressed samples of the rock stratum, as also tests on models, and pit observations using the impulse-seismic method.

G. I. Pokrovskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Micromeritics

(See also Revs. 4528, 4549)

4778. Deresiewicz, H., Stress-strain relations for a simple model of a granular medium, *J. Appl. Mech.* **25,** 3, 402–406, Sept. 1958.

With a model consisting of equal spheres arranged in a cubic lattice, an incremental stress-strain relationship is derived. To avoid the complexity due to nonlinearity of tangential force-displacement relationship, the normal component of the force is assumed to increase in constant proportion to the tangential one and the constant is greater than the coefficient of friction. By integration, the stress-strain relationship for certain type of loading and unloading is obtained, by which a criterion of failure is derived.

T. Mogami, Japan

4779. Duffy, J., and Mindlin, R. D., Stress-strain relations and vibrations of a granular medium, *J. Appl. Mech.* **24,** 4, 585–593, Dec. 1957.

See AMR **12** (1959), Rev. 2879.

4780. Chernov, A. P., Movement of small solid particles in a free air current (in Russian), *Dokladĭ Akad. Nauk SSSR (N. S.)* **105,** 6, 1170–1173, Dec. 1955.

Book—4781. Hammond, R., Separation and purification of materials, (Physical processes in the Chemical Industry. Vol. I), New York, Philosophical Library, 1958, x + 327 pp. $10.

This book is supposed to help make the university graduate (apparently synonymous with theoretician in the author's mind) into a practical executive, and to make the practical chemical engineer into a theoretically-trained executive. It accomplishes neither of these objectives. In fact, it falls short of any clear objective other than adding another mediocre book to the shelves.

Based on chapter titles the book proceeds in logical manner through separation of solids from solids, solids from liquids, solids from gases, liquids from liquids, gases from liquids, etc. A closer look obtained by laborious reading of the chapters discloses a very uneven presentation, replete with many descriptions of specific items of equipment that read like they were manufacturer's literature. Seemingly comparative data are frequently given but with little attention to their engineering validity or usefulness.

The book is, in reviewer's opinion, to be avoided by all who wish to be informed. Reading of almost any of the recent chemical engineering texts would be a better use of the young engineer's time.

C. L. Coldren, USA

4782. Kharlamov, P. V., Linear integral of the equations of motion of a heavy solid body (contained) in a liquid (in Russian), *Trudĭ Donetsk. Jndustr. In-ta* **20,** 51–67, 1957; *Ref. Zh. Mekh.* no. 3, 1958, Rev. 2579.

An investigation is made of the motion of a heavy solid body in a homogeneous ideal incompressible unbounded liquid, making the assumption that the weight of the body is equal to the weight of the liquid displaced by the body. Taking his lead from Chaplygin the author extends his investigation to cover the case where the center of gravity of the body does not coincide with the center of gravity of the volume of liquid displaced by the body. The form of kinetic energy is established in the presence of a linear integral, and possible exceptional cases are gone into. The presence is established of a special straight line in the body and its properties are laid down. The problem merges with the integration of Riccati's equations and in the general case is not solved in quadratures. Special cases are examined where the problem can be solved by quadratures.

A. K. Nikitin

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4783. Maslow, V. E., and Marshak, J. L., Investigation into absorption of solid particles in suspension by the film of liquid at vortex flow of motion (in Russian), *Teploenergetika* no. 6, 63–70, June 1958.

Paper describes the results of an experimental investigation into absorption process of solid suspension particles by viscous liquid film and the influence of various factors on this process.

From authors' summary

4784. Vagas, I., Application of the Laplace transformation to settling basin hydraulics (in Hungarian), *Hidrológiai Közlöny* **38,** 2, 135–137, Apr. 1958.

In case of settling phenomena where the settling curve of the Sierp-type can be interpreted, and can, with sufficient approximation, be substituted by an exponential function having a negative exponent, the value of the complementary settling efficiency $\eta k = 1 - \eta\ddot{u}$ derived from the settling efficiency $\eta\ddot{u}$ is one of the characteristics of the invariant flow function of a form $\sigma = \sigma(t)$, proportionate to the Laplace transformation function. Should no possibility exist to replace the settling curve by an exponential function with a negative exponent, a linear operator should be understood instead of the Laplace transformation.

It follows from the foregoing that the determination of the settling efficiency on basis of the mean flow-through velocity is only correct by the application of a coefficient α similar to the Coriolis coefficient.

From author's summary

4785. Bazilevich, A. I., Principles of resistance during structural motions of two-phase liquids (in Russian), *Nauch. Zap. L'vovsk. Politekhn. In-ta* no. 31, 93–108, 1955; *Ref. Zh. Mekh.* no. 3, 1958, Rev. 3094.

A short account is given of the present state of knowledge on the physico-chemical properties of clay suspensions; Bingham's principle is referred to and the known concepts regarding the regimes of the motions of two-phase liquids are mentioned. At IV (in the paper), known solutions are given of the motion of two-phase liquids in a round cylindrical pipe, in a circular space, and between two parallel plates. The article contains no new results.

A. Kh. Mirzadzhanzade

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4786. Fedorov, N. F., Losses of energy during the motion of heterogeneous liquids along pressurized pipe-conduits (in Rus-

sian), *Nauch. Trudi Leningr. Inzh.-Stroit. In-ta* no. 25, 5–13, 1957; *Ref. Zh. Mekh.* no. 3, 1958, Rev. 3069.

Experimental data are given regarding the energy losses when clayey pulps, lake and canal ooze and also paper pulp are passed through pipes. For the calculation of loss of energy during the motion of clay-water mixtures the formula of L. Kh. Maksimov is recommended $V = CR^{0.66} J^{0.5}$ where V is the speed of motion of the mixture, R the hydraulic radius, J the hydraulic deviation, C the coefficient, depending on the viscosity and consistency of the mixture. For the determination of the loss of energy during the motion of lake ooze the formula of N. P. Demin is recommended

$$h_{100} = \left(0.0035\frac{\theta^{0.6}}{d^{1.6}} + 0.23\frac{V^2}{d^{0.8}\eta^{0.2}}\right)\gamma$$

h_{100} is the loss of pressure in 100 m, θ the limiting shear stress in dynes/cm^2, η the plastic viscosity in poises, γ the specific weight in the ooze. The energy losses during the movement of canal ooze are presented in curves, drawn in accordance with the author's investigational data. The energy losses during the motion of cellulosic masses are recommended to be determined by the curves of the relation $i = f(V,Q)$, drawn in accordance with the investigational data of L. E. Volkov. Based on the results of the investigations he made, author puts forward a series of general deductions and examines the causes of anomolous behavior of heterogeneous liquids in pressurized pipe conduits in relation to the water. V. I. Gotovtsev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4787. Brun, R. J., Cloud-droplet ingestion in engine inlets with inlet velocity ratios of 1.0 and 0.7, *NACA Rep.* 1317, 35 pp., 1957.

See AMR **9** (1956), Rev. 1860.

4788. Zharnyl'skii, I. M., Hydraulic losses in a layer of a grain pile during grain-cleaning (in Russian), *Zap. Leningrad Z.-Kh. In-ta* **12,** 247–251, 1956; *Ref. Zh. Mekh.* no. 3, 1958, Rev. 3073.

Some ideas are advanced regarding the evaluation of the resistance of heaped grain in the grain-cleaning process. The movement of the air through a layer of grain is examined, as is also the motion of the parallel action of assemblies of pipe conduits, the resistance in which is a combination of friction resistance along the length (of the pipes) and the increased turbulence of the flow because of local resistances. A computation is made of the order of hydraulic losses in the grain layer. U. N. Gusev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4789. Brown, R. L., and Richards, J. C., Exploratory study of the flow of granules through apertures, *Trans. Instn. Chem. Engrs. Lond.* **37,** 2, 108–119, 1959.

Measurements were made of the flow of dry granular materials from a series of cylindrical vessels ranging from 1.45 to 14.6-cm diam through circular orifices from 0.112 to 5.03-cm diam located centrally in horizontal bases. The materials covered a narrow range of size, the mean grain size ranging from 0.020 cm to 0.11 cm. With sufficiently wide containers, the flow-rate is independent of the container dimensions. Further measurements on flow through slits and elliptical orifices are shown to be correlated satisfactorily in terms of a perimetral diameter $H = 4$ (area/perimeter). For flow from wide vessels all of the data may be represented by means of the dimensionless groups ψ and (K/H), where $\psi = Q/\rho A(gP)^{1/2}$. The form $\psi = \beta(H/K)^{1/2} \exp(-\gamma K/H)$ satisfactorily fits all the data for flow from wide vessels. The constants β, γ may be related to the angle of repose of the material, but further data are required. For a given size of any of the materials the flow from narrow vessels has the form $\psi = f(H/K, H/T)$. For spherical beads this function is independent of particle size, but this is not so for sharp sand. Consideration of experiments for flow from rough tubes suggests that the flow from narrow vessels is not influenced only by friction at the walls but also by interlocking of particles due to the proximity of the walls: it would appear that such interlocking may be determined, in part, by the angularity of the grains.

Typical flow-rates through apertures differing in size and in shape have been calculated to summarize the data.

From authors' summary

Porous Media

(See also Revs. 4554, 4559)

4790. Ubell, K., On the practical application of well hydraulics (in Hungarian), *Viz. Közl.* no. 3, 306–333, 1958.

The so-called nonequilibrium formulas use the S storage coefficient as a constant parameter. Author shows that this is not correct and introduces the following variable parameters: $S' = f(Q, T, \Delta s/\Delta t, r)$ and τ= the time of retarded outflow from the cone of depression.

Results of extensive field tests conducted by the author are given. The following parameters are investigated theoretically: determination of permeability coefficient; the storage coefficient; the radius of influence; the drawdown curve; discharge of well.

Many Russian, Hungarian, American and German papers on this subject are listed in the bibliography. Reviewer feels that this paper contains a large amount of information on well hydraulics. It would be desirable to have this material in a more generally accessible publication. A. L. Simon, USA

4791. Arkhanguelski, V. A., Filtering and flow through pipes of several-phase fluids (in Roumanian), *Studii Si Cercetari Mecan. Appl.* **9,** 2, 319–336, 1958.

First part of the paper concerns the filtering of a liquid and gas mixture through a porous medium. Problem is solved by considering a series of successive instants to satisfy the continuity conditions.

Second part applied the foregoing method to the problem of dislocating the oil from oil deposits with the aid of water.

Finally, paper deals with the flow of a liquid and gas mixture through oil wells. Problem is solved by means of the impulse theorem and of empirical relations.

D. Gh. Ionescu, Roumania

4792. Guseinov, G. P., and Babich, E. S., Displacement of gas-containing petroleum by water, taking into account the residual saturation by petroleum in the displacement zone (in Azerb.) *Trudi Azerb. N.-i. In-ta po Dobyche Nefti* no. 3, 106–113, 1956; *Ref. Zh. Mekh.* no. 3, 1958, Rev. 3079.

A flow is investigated when three zones are present: (1) petroleum zone with free gas, (2) intermediate zone, where both petroleum and water are present, where there is no free gas and where the permeability for the water has a constant value, (3) border water zone, extending to the contour of feed. Balancing equations are obtained and a formula for the pressure in relation to the petroleum saturation. The results for the calculation of a round stratum, for different values for the residual petroleum saturation in the intermediate zone, are presented in the form of tables and graphs. V. L. Danilov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4793. Marshall, T. J., The diffusion of gases through porous media, *J. Soil Sci.* **10,** 1, 79–82, Mar. 1959.

The effect of the obstruction of solid on the permeability of porous media is examined. From this it is concluded that, in

Penman's equation for diffusion of gases through porous media, the constant 0.66 should be replaced by $\varepsilon = \frac{1}{2}$ where ε is the porosity. From author's summary

Geophysics, Hydrology, Oceanography, Meteorology

(See also Revs. 4441, 4508, 4529, 4530, 4531, 4549, 4639, 4641, 4643)

4794. Gol'tsman, F. M., Graphoanalytical method of seismic wave frequency analyses in the wide band of frequencies (in Russian), *Vestnik Leningrad Univ.* no. 22, 76–88, 1957.

Construction of the complex spectrum of a seismic wavelet by using a sampling function is well known in the theory of communications (Shannon's "Sampling theorem"). Nomograms and tables are given to compute coefficients of a Fourier series representing the spectrum. The method allows to obtain 36 points of the spectrum placed equidistantly in the frequency band. An example is given.

Reviewer believes that this method is worthwhile only when electronic computing equipment is not available.

V. N. Baranov, France

4795. Gol'tsman, F. M., Graphoanalytical method of the frequency analysis of seismic waves (in Russian), *Vestnik Leningrad Univ.* no. 16, 45–56, 1956.

Method is presented to compute the amplitude- and phase-spectrum of a seismic signal from a trace of the seismogram. Every arch of the trace is identified with an arc of a sinusoid. Then an analytical expression of the spectrum is established and a method of its numerical computation is given. This method fails when the high-frequency components of the signal are not negligible.

There is an error in the first formula (p. 47): t in the expression $\cos(nt/\tau_k)$ must be replaced by $t - \theta_k$.

V. N. Baranov, France

Book—4796. Dub, O., Limnology, a hydrology of lakes and swamps [Limnologia, hydrologia jazier a barín], Bratislava, Slovenská Akadémia Vied, 1953, 109 pp. Kčs. 29.

A concise sketch of limnology, particularly of Slovakia, includes: morphometric measurements and derivations; heat regime, ice phenomena, physical and chemical properties; swamps and their hydrological significance. 13 lakes and 7 swamps are shown in illustrations. S. Kolupaila, USA

4797. Szigyarto, Z., Recurrence of hydrological events (in Hungarian), *Hidrológiai Közlöny* **37**, 4, 325–329, 1957.

Paper deals with the time of recurrence of hydrological events occurring once a year, *e. g.* river stage, discharge, etc., appearing at a fixed time of the year in some section of a watercourse.

In discussing the problem the author proves that, if the probability of occurrence of the investigated event is p ($c \leqslant p \leqslant 1$) and the occurrence or absence of the event in subsequent years is independent of the events of the preceding years, the probability of the event recurring within the following k years after the previous occurrence of same can be expressed by

$$p\,(\xi < k) = \sum_{k=1}^{x-1} p\,(1-p)^{k-1}$$

Thus the distribution of the length of the recurrence period is a so-called *negative binomial* or *Pascal* distribution.

The function values of the *Pascal* distribution are tabulated and the expected variations of the values and that of scatter are illustrated.

Paper also points out that the same distribution pattern will be obtained if, taking any arbitrary year as a start, the distribution of time length up to the first occurrence of the event is being sought. It is also emphasized that the taking of the average $1/p$ year recurrence of the event into account instead of that of p probability is justified in case of independence only.

From author's summary

Book—4798. Trupl, J., Short duration rainfall intensities in the drainage area of the Elbe, Oder and Morava [Intensity krátkodobých dešťů v povodích Labe, Odry a Moravy], Praha, Výzkumný Ústav Vodohospodářský Práce a Studie, 1958, Vol. 97, 76 pp. (Paperbound).

Recording rain gages and investigations of storm rains are reviewed in introduction. Data of storm rains in Czechoslovakia encompassing 1712 station years were applied for derivation of own formulas for rain intensity in terms of duration. Excellent sets of data for 98 stations are presented. Interesting conclusions are of particular value. Rainfall intensity of short duration is independent of total precipitation and its frequency. Short rain can be more intensive in plains than in mountains. Exponent of intensity curves is different in the investigated river basins. Four maps of maximum rain intensity of different duration conclude this very thorough study. S. Kolupaila, USA

4799. The works of the all-Soviet conference for the study of river discharge and the control of discharge in winter conditions, Moscow, 1952, Moscow, Izd-vo Akad. Nauk SSSR, 1954, 104 pp. 4r. 30k.; *Ref. Zh. Mekh.* no. 10, 1957, Rev. 11604.

4800. Skaballanovich, I. A., Evaluation of the effectiveness of bank drainage over a working period of 20 years (in Russian), *Gidrotekh. Stroit.* no. 10, 23–27, 1956; *Ref. Zh. Mekh.* no. 10, 1957, Rev. 11799.

A partial analysis is given of the results of working of a bank drainage scheme, protecting a town area from flooding, the level of the subsoil water having been raised by 5 m as the consequence of building a hydroelectric installation.

From author's summary
Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4801. Hidaka, K., Dynamics of ocean currents parallel to a long straight coast, *Geophys. Mag., Tokyo* **28**, 3, 357–365, Mar. 1958.

A theoretical result is given to the movement of water across a dynamical section perpendicular to a long straight coast. Having the data of the wind stresses on the surface and the geostrophic flows across the section, it is possible to compute the currents, taking the effects of both vertical and lateral mixings into consideration. Numerical computation is possible.

From author's summary by M. S. Weinstein, USA

4802. Ballabh, R., On Beltrami flows in the atmosphere, *Ganita* **8**, 1, 41–49, June 1957.

Beltrami flows in the atmosphere are investigated. Temperature is assumed constant; compressibility, gravity variation and earth curvature changes are neglected. Particular cases of the general equations are investigated. In the barotropic case the flow represents possible atmospheric currents, the streamlines are straight lines, the paths of particles are equiangular spirals. The velocity decays with time; the pressure and density decay with height.

In a second solution the paths of particles are circles in horizontal planes. The velocity does not decay with time; pressure is not a simple function of height. G. Miskolczy, USA

4803. Baxter, D. C., Some thermal aspects of the design of heated probes for measuring cloud water content, *Nat. Aero. Establ., Canada, Lab. Rep.* LR 72A, 18 pp. + 8 figs., Aug. 1958.

Thermal methods of measuring free water content in clouds offer certain advantages over other existing methods, particularly at high water contents. The heated wire with its low power requirement, high sensitivity and rapid speed of response best utilizes these advantages.

The performance of the heated wire is analyzed on a theoretical basis, and the effect of various operating parameters is illustrated. The transient and frequency responses are discussed, and the fast response compared with most other instruments demonstrated.

The probable error in recorded value of water content is calculated for a typical case. This leads to some conclusions regarding the recording of the various parameters involved.

Other forms of thermal instrument which have been proposed are discussed and compared with the heated wire.

From author's summary

Naval Architecture and Marine Engineering

(See also Revs. 4552, 4645, 4718)

4804. Guliev, Yu. M., Experimental investigation of the water resistance during the rolling of a ship (in Russian), *Sudostroenie* no. 6, 9–11, 1957; *Ref. Zh. Mekh.* no. 3, 1958, Rev. 2932.

Results are furnished for the experimental investigations on the water resistance to rolling on two types of craft (a cargo steamer and a cutter), using the method of free oscillations. These results showed good agreement with the calculated amplitudes obtained by the author and indicated that the water resistance to the rolling of the vessel is determinable by the linear-quadratic relation to the angular velocity of the rolling.

A. N. Shmyrev

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4805. Pershits, R. Ya., Nomograms for the determination of specification items in the hydrodynamic characteristics of ships' hulls (in Russian), *Sudostroenie* no. 11, 4–8, 1956; *Ref. Zh. Mekh.* no. 11, 1957, Rev. 12738.

Nomograms enable one to calculate the lateral hydrodynamic force and the hydrodynamic moment of the heading into the wind acting on the hull in the presence of angular drift. In combination with the circulation discontinuous theory of a wing of small threshold value elongation, the lateral hydrodynamic force presents itself in the form of a two-term relationship, the first term of which is proportional to the first degree of the angle of drift, while the second is proportional to the square of that angle. The hydrodynamic moment of heading into the wind is taken to be proportional only to the first step of the angle of drift. Three coefficients entering into the given relation were determined on the basis of tests of 14 duplicate models of the underwater part of the hull in an aerodynamic tunnel. The nomograms give the values of these coefficients in dependence on the ratios of the length of the hull to its width and of the depth to the length of the hull, and with further relationships with the coefficients of the volume of the amidship rib section and the volume of the submerged part of the diametrical plane. Comparison of the calculated results using the nomograms with the results of the tests with the models showed that the divergences did not exceed 10–15%.

K. K. Fedyaevskii

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4806. Reinov, M. N., Method of application of punched-card calculating machines to the calculations for a ship's statics (in Russian), *Sudostroenie* no. 5, 49–52, 1957; *Ref. Zh. Mekh.* no. 3, 1958, Rev. 2938.

A method is advanced for the utilization of a classifying machine and of a tabulator for the determination of the areas and static moments of the sections of a vessel (or parts). The rectangular field is broken up into squares with a sufficiently small side by means of straight parallel axes y and z. If y and z are coordinates of the square and a, t and θ are the parameters of the trace of the inclined waterline, then the squares for which $z - y \operatorname{tg} \theta < t$ will be found lower than the water line; in the opposite case, higher. For each square a punched card is prepared on which the numbers y, z and a set of numbers $t = A + z - y \operatorname{tg} \theta$ are punched in correspondence with the set of accepted θ (A is a constant). Such sets of punched cards are prepared once for all subsequent calculations. The section figure, bounded by the outline and the waterline trace, is composed of squares which replace its actual boundaries by stepped ones. Then the number of squares entering the figure is approximately proportional to its area, while the sums of their coordinates are proportional to the statical moments. Sorting out the punched cards for the squares entering the figure, classifying them by their increased t for a given θ and passing them through a tabulator, tables are obtained for the areas and statical moments of the section for the accepted series for t and θ. Schemes are indicated for the solution of problems met with in calculations for unsinkability and in diagrams for the statical metacentric stability of vessels.

V. G. Sizov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Book—4807. Papkovich, P. F., Studies on the stability of a ship (in Russian), Leningrad, Sudpromgiz, 1956, 680 pp. + illus. 21r 75k; *Ref. Zh. Mekh.* no. 11, 1957, Rev. 13369.

A collection of selected studies of P. F. Papkovich on the structural mechanics of a ship, written in the period 1923–1946 and published in not easily available editions, or as separate bulletins, now in the category of bibliographical rareties; some of the studies are printed for the first time. The papers concern the methods of determination of external forces reacting on the hull of the vessel, the determination of stresses in the various constructional parts of the hull, and problems relating to the standardization of the stability of the ship. The book included 35 studies: (1) The work of A. N. Krylov in the field of basic ship-constructional principles. (2) Brief summary of the evolution of the problem of internal forces in the study of the general strength of the ship. (3) Analysis of supplementary bending moments appearing in the hull of a straight-walled ship on the correct sinusoidal surge. (4) Distribution of the general bending moment between the ship's hull and the floating dock raising the hull. (5) Influence of bending of tanker barges on the amplitude of stresses set up in them. (6) How to organize the study of forces imparted by waves to the ship. (7) Technics of deformation measurements of ships' hulls. (8) Experimental investigations of ships for use in Arctic seas. (9) The wreck of the steamer "Khar'kov."

(10) Questions regarding the stability of ships of the "Liberty" type. (11) Principles in design of long above-maindeck superstructures. (12) Determination of the deformation of the top ring of a rigid cylinder from the general deflection of the ship. (13) Tangential stresses appearing in the sheathing of the ship from its general deflection. (14) Stresses in the welded facing seams. (15) Calculation for intersecting joints. (16) Calculation for framework ribs. (17) Selection of the spacing between the vertical bracing components of the hull. (18) Width of the equivalent belt of the sheath-covering taking part in the deflection of its assembly. (19) The reduction coefficient for the plates of the double bottom, supported by a transverse assembly. (20) Reduced width of flanges

giving by means of sheathing of the bulkheads their final assembly. (21) The reduction coefficient of plates carrying the transverse load. (22) Reduction coefficient of rectangular freely supported plates having initial curvature. (23) Determination of the longitudinal forces in plates, elastically fastened along the long rectangular contour.

(24) Selection of fundamental functions in the Raleigh-Ritz method. (25) Approximate method for the construction of compressed braces, intended for the taking up of complex loads. (26) Local deflection of belts of double-T beams near points of loading by their concentrated forces. (27) Strength of a plane form of deformation of a flatly compressed ring, freely supported on the external contour. (28) Cylindrical shells under stress in the ribbing. (29) Calculation formulas for the check of strength of a cylindrical shell. (30) Deflection of a round ring and cylindrical shell, emerging as the result of initial departure from their correct forms. (31) The coefficient of thrust of spherical partitions. (32) Bases of the theory of elastic-plastic deflection of statically-determinable beams. (33) Calculation for redundant constructions by the method of limit loads. (34) Work of a deck flooring. (35) Necessity for regulating the calculation values for the inevitable distortion of the sheathing of river craft.

The works in this book appear to be very valuable supplements to the known books by Papkovich ["Theory of elasticity," Oborongiz, 1949; "Structural mechanics of the ship," Sudpromgiz, 1941-1947]. The selection was edited by O. A. Kotsyubin. The book also contains an account of the life and activities of Papkovich, written by V. V. Ekimov.

A. S. Vol'mir

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4808. Shebalov, A. N., An approximate method for the determination of the position of the center of pressure of the hydrodynamic forces during the ship's motion (in Russian), *Trudî Leningr. Korable stroit. In-ta* **18,** 105-110, 1956; *Ref. Zh. Mekh.* no. 3, 1958, Rev. 2926.

The problem is investigated of the motion of a cylindrical body of infinite length with an arbitrary (for its section C) shape of contour in the direction perpendicular to the generatrix of the cylinder. An expression is recorded for the determination of the point of intersection with the axis y (the vertical axis of the coordinates) with equally acting forces of pressure on the contour C. At the same time the moment of forces M_0, acting on the contour, is determined on the assumption that the outline of the distribution of pressures on the contour is known (found, for instance, by experimental means). As an example, a contour of elliptical form is examined; here the general expressions for the moment of forces M_0 and the point of intersection of the equally acting forces of pressure with axis y are continued to the calculation formula stage. On the basis of the method of plane sections the formulas obtained are extended to cover three-dimensional bodies—ships with an elliptical form of ribs (framework). The comparison made between the calculation and experimental values of magnitude y/T (where T is the sagging of the ship) for the model of a river vessel, show, the author's claims, that the formula obtained can be used for approximate calculations for the point of application of hydrodynamic forces of pressure when the ship is moving.

A. A. Kostyukov

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4809. Shebalov, A. N., On the interaction of an engine with a thin hull of a ship when going astern in an unbounded ideal liquid (in Russian), *Trudî Leningr. Korablestroit. In-ta* no. 14, 112-117, 1954; *Ref. Zh. Mekh.* no. 3, 1958, Rev. 2937.

An investigation is made of the steady motion of an engined vessel going astern in an unbounded ideal liquid. The engine's action is replaced by the action of an evenly distributed system of discharges on the plane of the engine's disk (bed-plate). The ship's action is replaced by a continuous distribution of springs (walls) along the surface of the vessel, with an intensivity of γ. When going astern the vessel finds itself in a stream set going by the engine. Because of this one more supplementary potential of velocities is introduced. Author shows that the problem can be allied to the integral equation for the determination of the intensivity of the springs γ and to the general method of presentation of the coefficient of suction.

M. D. Khaskind

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

4810. Kuhring, M. S., The Comox torpedo—A Canadian contribution towards hydrofoil development, *Nat. Res. Counc. Canada, Div. Mech. Engng. Rep.* ME-210, 40 pp., June 1958.

4811. Kumai, T., Response of the higher modes of the hull vibration of a large tanker, *European Shipbldg.* **7,** 5, 126-133, 1958.

4812. Gofman, A. D., The work of a flapping wing in its capacity as an engine (in Russian), *Trudî Leningr. Korablestroit. In-ta* no. 18, 231-238, 1956; *Ref. Zh. Mekh.* no. 3, 1958, Rev. 2951.

Results are furnished for tests on a model of a flapping wing behind a hull, obtained in the tank of the Leningrad shipbuilding institute, and evaluations are made of the prime-mover characteristics of three variants of the flapping wing. For purposes of comparison with the theoretical data a calculation is given for the pressure coefficient in relation to the relative entry. The calculation is based on the utilization of V. V. Golubev's formula for a flapping wing of infinite span, in which the parameters of the vortex track are selected in the same way as for the unbounded free vortex track, while the intensity of the vortices γ are connected with the circulation around the wing Γ by the relation $\gamma = 2\Gamma$. For transfer to the flapping wing of small elongation use is made of the same formula for the pull on the wing of infinite span, but the expression for Γ is taken from the approximate formula, proposed by V. V. Golubev for the wing of small elongation in a stationary flow, into which in its turn a reduction coefficient is introduced, for taking account of the nonstationary effects. Taking these nonstationary effects into account is carried out according to the theory of the thin wing with continuously running off vortices. In accordance with the data given in the paper it can be taken that the calculations made agree with the test results.

M. D. Khaskind

Courtesy Referativnyi Zhurnal, USSR
Translation, courtesy Ministry of Supply, England

Friction, Lubrication and Wear

4813. Tabor, D., Friction between tire and road, *Engineering* **186,** 4842, 838-840, Dec. 1958.

The physical basis for the frictional force of rubber is described by two terms, the adhesion term and the deformation term. In simple sliding both terms are operative, but in rolling the deformation term predominates. By comparing forces exerted in rolling and sliding, the importance of the deformation term in sliding is demonstrated. Experiments in which lubricated conical steel sliders were slid over black tread rubber demonstrated that the friction could almost entirely be accounted for by hysteresis in the rubber. When water was used as a lubricant, this remained true up to values of unit stress of some 500 lbs/sq in. Increased friction at higher values was attributed to penetration of the hydrodynamic fiber followed by tearing of the rubber.

The implications of this work for highway engineering and pneumatic tire design are discussed.

F. T. Barwell, England

4814. Ito, S., Honda, K., and Ishiyama, K., Severe wear of pearlitic steel weld metal, *J. Mech. Lab. Japan* **4,** 1, 15–21, 1958.

A study has been made on the severe wear of pearlitic steel weld metal by rubbing at a speed of 2.5 cm/s under a load of 40 kg in unlubricated conditions. In this range of the test conditions, once equilibrium surface conditions are established, wear obeys the relationship $W = KL/Pm$ where W is the wear rate, L is the load, and Pm is the flow pressure of the material. This value of K indicates the wear property of the weld metal.

The relationship between wear property and microstructure or chemical composition is considered. By microscopical examinations of the wearing surfaces, it has been possible to form a picture of the movement of the wear debris. From authors' summary

4815. Jakobsson, B., and Floberg, L., The partial journal bearing (in English), *Trans. Chalmers Univ. Technol.* no. 200, 60 pp., 1958.

Authors treat partial journal bearings with minimum film thickness at the trailing edge. In the case of this class of bearings only positive pressures arise all over the bearing area. Thus, vaporization needs not be considered. Moreover one has zero pressure along the bearing edges and sides. These latter facts are to be respected as boundary conditions in solving Reynolds equation. Authors made their calculations under the assumption that the viscosity of the lubricating fluid is constant across the bearing area.

For infinitely wide bearings an exact solution is deduced, whereas for bearings of finite width only an approximate solution can be found. For this purpose authors imagined the bearing area divided into a rectangular network and replaced the Reynolds differential equation by a difference equation connecting the pressure in, respectively, one grid point of this network with the pressures in its four neighboring grid points. Setting up such an equation for each grid point with consideration of the boundary conditions, authors obtained a system of equations which was solved by the aid of an electronic computer.

Calculations were performed for bearings with bearing angles 180°, 120°, 90°, 60°, and 30° and width-diameter ratios ∞, 1, 1/2, and 1/4 at the eccentricities 0.2, 0.4, 0.6, and 0.8. For these cases load capacity, load angle, oil flow, power loss, and relative power loss are determined. The results are given in tables and curves. Then authors instruct how to design a partial bearing which will have a minimum power loss for given load capacity, given angular velocity, and given minimum oil film thickness.

U. Rost, Germany

4816. Ozdas, M. N., Grooving and film extent in journal bearings (in English), *Bul. Istanbul Tekn. Univ.* **11,** 1, 14–28, 1958.

An experimental investigation was carried out with transparent bushings having oil entry by means of a single hole, a double-axial groove or a circumferential groove in order to study the behavior of the lubricant film under static loads using ultra-violet irradiation technique.

Preliminary results showing the effect of grooving, oil supply pressure and Sommerfeld variable on the lubricating film are presented. From author's summary

4817. Osterle, J. F., Chou, Y. T., and Saibel, E. A., Effect of lubricant inertia in journal-bearing lubrication, *J. Appl. Mech.* **24,** 4, 494–496, Dec. 1957.

See AMR **11** (1958), Rev. 1843.

4818. Loitsianskii, L. G., Theory of the spherical bearing (in Russian), *Prikl. Mat. Mekh.* **20,** 1, 133–135, Jan./Feb. 1956.

4819. Schutten, J., Baron, H., van der Hauw, T., and van Deenen, P. J., Dynamic measurement of film-thickness in gas bearings, *Appl. Sci. Res.* (*A*) **7,** 6, 429–436, 1958.

A method is described to determine the position of the sliding part of a bearing relative to the stationary one, as well as any vibration of the bearing with an accuracy of about 0.1 μm, by measuring capacitance changes between the sliding member and probes mounted in the stationary one. The resulting figure is displayed on an oscilloscope screen. The design for a gas-lubricated journal bearing is discussed. From authors' summary

Letter to the Editor

4820. Re: AMR **12,** Rev. 2573 (May 1959): **Hansen, C. F., Approximations for the thermodynamic and transport properties of high-temperature air,** *NACA TN* 4150, 43 pp. + 8 tables + 11 figs., Mar. 1958.

Reviewer of the above-mentioned review wishes to acknowledge an unfortunate error resulting from the accidental omission of a line in transcribing for presentation to AMR. Thus, what read "...and exchange corrections. Result is to seriously..." should have read "...and exchange corrections. Transport calculations are also made assuming a fully ionized gas. Result is to seriously ...."

In addition to noting the obvious inconsistency caused by the above omission, Dr. Hansen has raised the following objections to the review:

1. Because of the increased thermal conductivity with no appreciable increase in momentum transfer, the Prandtl number of fully ionized air is more likely of the order of 1/100 rather than 1/2 as suggested in the review.

2. The electron-atom cross sections obtained from the classical model of the polarization interaction give nearly the same answer as the more rigorous quantum mechanical calculations and not incorrect estimates as stated by the reviewer.

3. The paper's conclusions regarding a favorable comparison between heat-transfer measurements and the calculated transport properties were misinterpreted by the reviewer as justifying the estimates given.

Reviewer wishes to acknowledge that the calculations of Dr. Hansen do bear out his correctness on the second point. He also wishes to acknowledge that on the third point he misinterpreted the author's intent. With regard to the first point concerning the Prandtl number the reviewer wishes to clarify his own statement by noting that although he acknowledges that the Prandtl number calculated by Dr. Hansen is of the order of 1/100, this reviewer believes that because of the high thermal conductivity of the electrons compared to the gas this Prandtl number based on a single temperature loses its significance. If the finite rate at which energy is transferred through elastic collisions between the light electrons and the heavy atoms is taken into account then this reviewer still feels that the actual effective Prandtl number of the air will be about 1/2. R. F. Probstein, USA

Books Received for Review

Academie Royale de Belgique—Annuaire Pour 1959, Bruxelles, Palais des Academies, Vol. 125, 1959, 251 pp. + 59 pp. of biographiques.

BLOK, H., editor, Round-table discussion on marine reduction gears (Proceedings of a Symposium, University of Technology, Delft, Holland, April 1957), Delft, Holland, University of Technology, 1958, vi + 150 pp. (Paperbound).

BODEWIG, E., Matrix calculus, second edition, New York, Interscience Publishers, Inc., 1959, xi + 452 pp. $9.50.

BOOTH, A. D., Automation and computing, New York, The Macmillan Co., 1959, 158 pp. $5.

BRETSCHER, E., AND HUGHES, D. J., Soviet reviews of nuclear science (Translation of Vol. 3, no. 11 of Atomnaya Energiya November 1957 on the 40th Anniversary of the October Revolution), New York, Pergamon Press, Inc., 1959, 108 pp. + index. $5.

CARSLAW, H. S., AND JAEGER, J. C., Conduction of heat in solids, second edition, New York, Oxford University Press, 1959, viii + 510 pp. $13.45.

CHENG, D. K., Analysis of linear systems, Reading, Mass., Addison-Wesley Publishing Co., Inc., 1959, xiii + 431 pp. $8.50.

CHESTNUT, H., AND MAYER, R. W., Servomechanisms and regulating system design, Vol. 1, second edition, New York, John Wiley & Sons, Inc., 1959, xvii + 680 pp. $11.75.

Conference on Fracture; An International Seminar on the Atomic Mechanisms of Fracture, April 12–14, 1959, Swampscott, Mass., 26 papers (Paperbound).

COXON, W. F., Flow measurement and control, New York, The Macmillan Co., 1959, x + 312 pp. $11.

FOPPL, L., AND MONCH, E., Praktische Spannungsoptik, second edition, Berlin, Springer-Verlag, 1959, xi + 209 pp. DM 30.

FRENCH, A. P., Principles of modern physics, New York, John Wiley & Sons, Inc., 1958, ix + 355 pp. $6.75.

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HAYES, W. D., AND PROBSTEIN, R. F., Hypersonic flow theory (Vol. 5 of Applied Mathematics and Mechanics), New York, Academic Press, Inc., 1959, xiv + 464 pp. $11.50.

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LAZARKIEWICZ, S., AND TROSKOLANSKI, A. T., Pompy Wirowe, Warszawa, Panstwowe Wydawnictwa Techniczne, 1959, xvi + 553 pp. Cena zl. 80.

Modern computing methods, New York, The Philosophical Library, Inc., 1958, vi + 129 pp. $8.75.

MURPHY, G. J., Control engineering, Princeton, New Jersey, D. Van Nostrand Co., Inc., 1959, xii + 385 pp. $7.50.

NOBLE, B., The Wiener-Hopf technique, New York, Pergamon Press, Inc., 1958, x + 246 pp. $10.

PEARSON, C. E., Theoretical elasticity (Harvard Monographs in Applied Science, 6) Cambridge, Mass., Harvard University Press, 1959, 218 pp. $6.

PIPPARD, A. B., Elements of classical thermodynamics, New York, Cambridge University Press, 1957, vii + 165 pp. $4.75 ($2.75 paperbound).

SASIENI, M., YASPAN, A., AND FRIEDMAN, L., Operations Research methods and problems, New York, John Wiley & Sons, Inc., xi + 316 pp. $10.25.

SCHENCK, H., Jr., Heat transfer engineering, New York, Prentice-Hall Publishers, Inc., 1959, ix + 310 pp. $9.25.

SCOTT, R. B., Cryogenic engineering, Princeton, New Jersey, D. Van Nostrand Co., Inc., 1959, xi + 368 pp. $5.60.

SEMENOV, N. N., Some problems in chemical kinetics and reactivity, Vol. 2 (Translation from the Russian by M. Boudart), Princeton, New Jersey, Princeton University Press, 1959, 331 pp. $4.50. (Paperbound).

TEMPERLEY, H. N. V., Changes of state (A mathematical-physical assessment), New York, Interscience Publishers, Inc., 1956, xi + 324 pp. $7.50.

Translators, Translations: Services and Sources, Project of Georgia Chapter, New York, Special Libraries Association, 1959, 60 pp. (Paperbound).

WARFIELD, J. N., Electronic analog computers, New York, Prentice-Hall Publishers, Inc., 1959, ix + 175 pp. $6.

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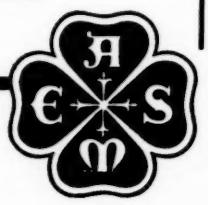

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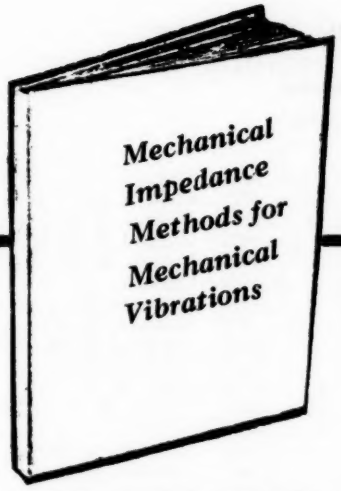

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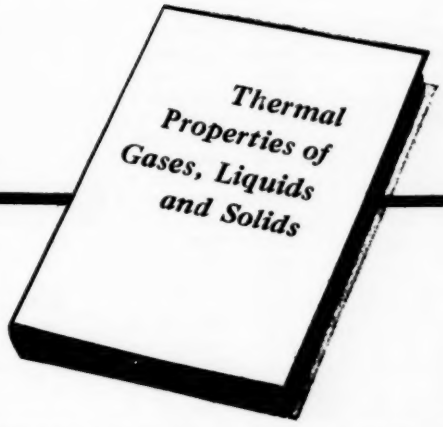

This book brings together the forty-two papers which were presented at the February 1959 Symposium sponsored by theASME Heat Transfer Division.

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